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THE RED STAIN IN THE WOOD OF BOXELDER[1]

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INTRODUCTION

The red stain (pl. 2) so commonly met with in the wood of living boxelder trees (*Acer negundo* L., syn. *Negundo aceroides* Moench.) has almost come to be recognized as a character in the identification of this species. Few have stopped to consider the cause of such vivid coloring, assuming in many cases that it was a normal character of the wood. During the years of 1921 and 1922 considerable attention was drawn to this wood and to the stain which characterizes it, in efforts to discover the cause of the stain and to find means of preventing it. The vivid coloring is often attractive, yet due to its irregular distribution in the heartwood and its presence, at times, in the sapwood and its less attractive shades and associated colorings, the wood so stained is often found objectionable. The wood of boxelder is used to a considerable extent for certain classes of furniture, interior finish, woodenware, cooperage, and paper pulp. In such cases the clear, creamy white color of normal wood is preferred. Therefore the disease was considered to be of sufficient economic importance to warrant an investigation of the red stain.

THE DISEASE

HISTORY

The earliest and possibly the only reference to the red stain in boxelder, in so far as the writer could determine, was published in Germany in 1880 by Eidam,[4] who states that undoubtedly some unknown fungus is responsible for the stain. He notes that it is a very characteristic stain and that it can not be confused with the discolorations produced in coniferous wood by *Trametes pini* and *Fomes annosus* (*Trametes radiciperda*).

The writer's attention was first called to this vivid stain in November, 1920, when samples of boxelder from a Tennessee lumber company were received for examination. Microscopical examination disclosed the hyaline to slightly colored hyphae of an unknown fungus within the cells of the red-stained areas. Cultures on malt agar, made by using fragments of the red to pink colored wood, showed a white fungous growth attended by a pink discoloration of the agar, after incubation for seven days. In some of the tubes the white aerial mycelium seemed to dis-

[1] Accepted for publication June 25, 1923.

[2] The writer is greatly indebted to Dr. C. D. Sherbakoff for naming the fungus discussed in this paper and for furnishing a description of it with a text figure and colored plate.

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[4] EIDAM, E. BLAUGRÜN GEFÄRBTES HOLZ VON BIRKEN UND BUCHEN UND BLUT-BIS CARMINROTH GEFÄRBTES VON ACER NEGUNDO. *In* Jahresber. Schles. Gesell. Vaterländ Cult., Jahrg. 58 (1880), p. 188–189. 1881.

appear after twenty to twenty-five days and a faintly purplish, slimy layer appeared on the agar slant. Following this, a network of jelly-like substance formed on the sides of the tubes above the agar surface. Examination disclosed this growth to be the plasmodial strands of a Myxomycete which apparently had fed upon the hyphae in the cultures. At the end of thirty days no visible signs of hyphae were apparent. Three of the tubes continued to develop normal mycelial growth, and at the end of eight to ten days a brilliant carmine stain appeared on and slightly below the surface of the agar. A subsequent study of the spore forms showed this organism to be a species of Fusarium.

Following shortly on these observations the author had occasion to study several freshly felled boxelders on the campus of the University of Wisconsin. All of these trees showed an abundance of the red stain extending from the roots to the smaller branches. It is most commonly found in the heartwood, but in many cases the discolored zone appeared in the inner sapwood, and isolated patches and irregular areas of color appeared in the sapwood nearer the bark (pl. 2). Cultures were secured from samples cut from the trees and transfers made to prune and oatmeal agars. Information from other parts of the United States where boxelder is cut in considerable quantity for commercial use indicates that this stain is very common and that it is a peculiar characteristic of this tree.

A preliminary note on the red stain of boxelder was published in March, 1922, by the writer in an article dealing with the economic aspects of certain stains commonly found in wood.[5]

The following taken from the article by Eidam([4]) is of historical interest in connection with the red stain in boxelder; he says:

> Greek mythology speaks familiarly of the dryads, those nymphs who live in trees and are even said to suffer death with their felling. The ancient Greeks had been supported not a little in their poetic faith through the discovery of the blood red wood. We present-day skeptics take our microscope and prosaically attempt to probe the matter to the bottom.

Hedgcock [6] has recorded the occurrence of a pink stain caused by *Fusarium roseum* (group) upon various species of pine lumber, but no record is noted of its occurrence within the living hosts.

HOSTS

Boxelder, so commonly used as a shade tree, is the principal host of the organism producing red stain in the heartwood and to a less extent in the sapwood of the living tree. In this species of wood the stain has often been traced throughout the heartwood in freshly felled trees from roots two inches or less in diameter through the trunk into the main limbs and out into the branches which measured from one to three inches in diameter. Similar but paler discolorations have been observed in the wood of yellow poplar (*Liriodendron tulipifera* Linn.), gumbo limbo (*Bursera simaruba* (Linn.) Sargt.), aspen (*Populus tremuloides* Michx.) and in white pine (*Pinus* sp.).

Reports have been received of a red stain appearing near the juncture of sapwood and heartwood in white oak, but samples of this material

[5] HUBERT, Ernest E. SOME WOOD STAINS AND THEIR CAUSES. *In* Hardwood Rec., v. 52, no. 11, p. 17–19, 4 fig. 1922.

[6] HEDGCOCK, George Grant. STUDIES UPON SOME CHROMOGENIC FUNGI WHICH DISCOLOR WOOD. *In* Mo. Bot. Gard. 17th Ann. Rpt., p. 59–114, pl. 3–12. 1906.

have not been examined. Eidam states that a similar "blood red" discoloration was noted in a piece of beech wood, and records the finding by Stein of a "beautiful violet stain" in the wood of lilac (*Syringa vulgaris*). A bright violet-red color has been observed by the writer in a piece of lilac wood in the wood collection of the Forest Products Laboratory.

CAUSE OF THE DISCOLORATION

The discoloration in the wood of boxelder is due to a soluble pigment secreted by the fungus which stains the wood tissues and cell contents and by the presence in the wood of colored hyphae. The older hyphae within the wood tissues contain the coloring matter, as do also the hyphae in most of the cultures. An experiment was conducted to determine whether the coloring matter was to be found in solution outside the hyphal threads. Two tubes of malt agar on which the organism had been growing for a period of eight days were emptied of their contents upon a paper filter. Warm distilled water was poured over the agar and the collected filtrate showed a distinct reddish color. The formation of brighter colors is apparently favored by an acid medium, probably by the degree of acidity, since the areas of the heartwood showing the bright red colors react quite strongly acid to litmus, while the yellowish to brownish areas accompanying these react but slightly.

That the coloring matter diffuses out from the fungus and is not confined to the lumen of the hyphal cells is evidenced by the observations that hyphae are not always found in the red colored tissues. Apparently the colored liquid diffuses considerably beyond the hyphae which produce it. The color fades somewhat when a red-stained boxelder board is exposed for a year to sunlight.

DESCRIPTION OF STAIN

The red stain in boxelder varies considerably both in shades of color and in uniformity of distribution throughout the tree. The color ranges on moist wood from a light coral red to hellebore red or carmine.[7] On dry wood the hues are less intense and range from light coral pink to jasper red.

Very often the stain in the heartwood does not show a uniform coloring, but is broken by irregular blotches of various sizes and of a deeper hue (pl. 3). These blotches indicate individual infections due to sapsucker injury. Very frequently the heartrots caused by *Collybia velutipes* Curtis, *Pleurotus ulmarius* Bull., *Fomes applanatus* Fr. or other polypores are found in the heartwood (pl. 3). In such cases the red stain is found bordering the decayed areas and frequently the decayed area contains the red stain which had previously surrounded it but had become invaded by the advancing rot organisms. No particular signs of antagonism to one another is exhibited in wood containing the red stain fungus and a heartrot organism. When the red stain is present in the same areas with *F. applanatus* the latter fungus produces narrow black zone lines along the outer boundaries of the decayed areas (pl. 3), but these lines are not consistently formed, so there is no indication that they are due to a reaction between the two fungi. Similar lines are formed by *Fomes applanatus* in the absence of other fungi.

[7] RIDGWAY, Robert. COLOR STANDARDS AND COLOR NOMENCLATURE. 43 p., 53 col. pl. Washington, D. C., 1912.

Quite often the sapwood shows scattered, irregular patches of red stain which end abruptly at certain annual rings. These isolated stained areas are interpreted as individual infections originated through the wounding of the cambium by sapsuckers. The brighter tints of red are more commonly found in these areas.

The absence of hyphae in many instances in the outer borders of the discolored area leads to the belief that the coloring matter spreads through the wood ahead of the hyphae.

PATHOLOGICAL ANATOMY

Eidam, referring to the red stain in boxelder, states that if mounts are made of transverse and longitudinal sections taken from the red areas of the wood then the parenchyma cells are seen to be frequently penetrated by a fungous thread which is colorless, the walls of the tracheids are so corroded that they easily fall to pieces, and particularly in the large pitted tracheids of *Acer negundo* (the fungus threads) weave matted cushions of large anastomosed hyphae filling the cells completely.

A preliminary study of the material so far collected on boxelder indicates that the fungus is to be classed as a stain organism rather than as a wood destroyer. Microscopical examination of radial sections of the red colored wood taken from infected branches reveals the fact that the outer regions of the colored areas rarely contain hyphae. Occasionally, in the central area of the branch, where the fungus has been present for some time, hyphae were found in the vessels and in the pith cells. Penetrations of the pith cell walls were noted. In the pith the hyphae are irregular in size, rarely branched, and of a jasper pink to ochraceous salmon color.

No evidence of corrosion of cell walls such as observed by Eidam was noted in the material so far studied. Whenever corrosion was observed it was invariably attributed to the decay-producing organisms accompanying the red-stain fungus. A Myxomycete, which apparently feeds upon the hyphae of the red-stain fungus, is often found associated with the red stain. The question arises whether this Myxomycete may not be responsible for the scarcity of the hyphae of the red-stain fungus in the wood.

GEOGRAPHICAL DISTRIBUTION

The geographical distribution of this disease may be assumed to coincide with the range of the boxelder. The disease is widespread in this country throughout the States of Wisconsin, Minnesota, Michigan, and South Dakota. Few reports of its occurrence have been received from regions outside of the Middle Western and Southern States. It is commonly met with in the raw material of the slack cooperage industry. In Tennessee, where the writer visited a large cooperage mill, the boxelder bolts could be picked out of a carload of mixed stock by means of the vivid red color in the heartwood and sapwood. From published data a similar stain in boxelder appears to occur in widely separated countries in Europe.[8]

ECONOMIC IMPORTANCE

Since the red stain in the wood infected by this Fusarium constitutes a blemish,[9] the grade of such stained material is considerably lowered

[8] EIDAM E. OP. CIT.

[9] According to standard grading rules a blemish of this type consists of a stain either superficial or deep in the wood which is not sufficiently objectionable to be classed as a defect.

and the loss suffered is in proportion to the reduced price. For uses where bright stain-free stock is required, the red-stained wood is rejected. However, the stained stock is used for many purposes where the discoloration meets with little or no objection, or where it is covered or painted. The fact that this fungus is often associated with decay-producing organisms in the heartwood of boxelder should cause some hesitation in using stained stock for purposes requiring sound material.

THE CAUSAL ORGANISM

TAXONOMY

The causal organism has been isolated repeatedly in pure cultures by using fragments of the red-stained wood. Pieces of wood taken from the stained areas, the surfaces thoroughly sterilized by washing in mercuric chloride, 1–1,000, and then washed in distilled water, when placed in sterilized moist chambers invariably developed a white to pinkish mycelium in the red-stained areas adjoining the unstained wood and to a less extent in the remaining red-colored areas. Spores collected from this mycelium proved to be typical of the genus Fusarium. The various types of spores obtained on the malt, prune, and oatmeal agars by transfers from the primary cultures, gave additional proof of its generic identity. Cultures on malt agar and on oatmeal agar were sent to Dr. C. D. Sherbakoff, Experiment Station, University of Tennessee, who kindly determined the species and submitted the following description of the causal organism:

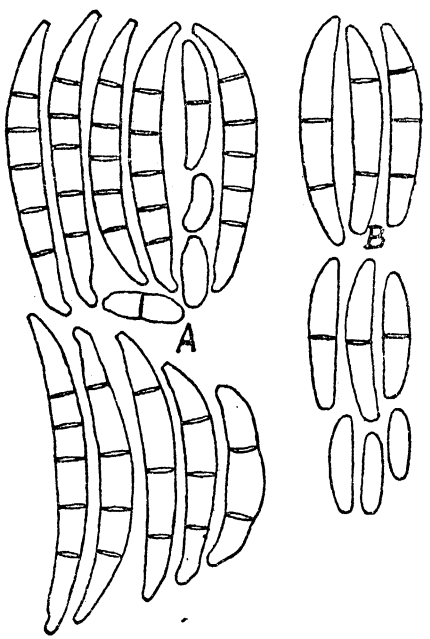

FIG. 1.—*Fusarium negundi* Sherb. A.—Sporodochial conidia from 30-day-old culture on oat agar plus 3 per cent glucose-maltose, in Petri-dish. B.—Free conidia from 3-day-old culture on corn-meal agar, in Petri-dish. Magnified 1,000 diameters. Drawing by Dr. C. D. Sherbakoff.

Fusarium negundi Sherbakoff (new species).

Sporodochial conidia 0 to 5–septate; 0 to 2–septate few, 3 to 5–septate common, 5–septate most numerous and measure 4.25 x 38.5 (4–6 x 34–42) μ; the spores are gradually attenuate toward the apex, pedicellate, somewhat more distinctly curved toward apex. Conidia borne singly on mycelial branches, few, 0–3–septate, ventrally nearly straight, apedicellate, apically attenuate. Aerial mycelium on most media in test tubes and in plates rapidly growing, even, fine, from white to carmine; substratum, in plates on agars with glucose, of carmine color. Large plectenchymic bodies (pseudo-sclerotia) common on oat agar. The sporodochial conidia much

resemble *F. incarnatum* (Rob.) Sacc., as per Wollenweber's figures in the supplement to his "*Fusaria* aut. *delineata*," but include none with more than 5 septa.

Habitat.—In red discolored wood of box elder, *Acer negundo* Linn., Madison, Wisconsin, United States of America.

Sherbakoff states that, "The general appearance of the fungus on hard oat agar in a test tube is shown in Plate 1. Free spore production on mycelium is very sparse and the conidia are of the type shown in Figure 1, B. Sporodochia in the media used are rarely produced, in fact only in one culture (a Petri-dish culture on hard potato agar plus 3 per cent dextrose-maltose) sporodochia appeared, and then in a comparatively large number, mostly one-fourth to 1 mm. in diameter, free, i. e., without a pseudoparenchymic base, with conidia of light-salmon color. When the culture was 8 days old the septation and size of conidia from the sporodochia were as follows: 0–septate very few; 1–septate, 1 per cent; 2–septate, not observed; 3–septate, 30 per cent, 3.5 x 31.5 (3.1–3.9 x 29–37) μ; 4–septate, 32 per cent, 3.85 x 35.7 (3.7–4.2 x 31.5–39) μ; and 5–septate, 37 per cent, 4.1 x 37.5 (3.8–4.2 x 35–40) μ. Another examination of conidia from the same sporodochia, when the culture was 30 days old, gave the following results: 0–septate, 2 per cent; 1–septate, 7 per cent; 2–septate, 2 per cent; 3–septate, 8 per cent; 4–septate, 9 per cent; and 5–septate, 72 per cent; the latter measuring 4.4 x 39.2 (3.9–6.1 x 34–42) μ. The conidia are shown in Figure 1, A."

MORPHOLOGY

The conidia (fig. 2, G.) are typical sickle-shaped spores with the characteristics as given by Sherbakoff. Macroconidia, microconidia, and chlamydospores are formed, both in artificial cultures and upon the exposed surfaces of the host, although up to the present time macroconidia have been found less frequently upon the host than the other forms.

A six-day-old culture on malt agar, No. 91, when examined, showed large septate hyphae, constricted at the septa, with contents varying in color from yellowish to bright red and containing many large vacuoles (fig. 2, K.). Anastomosing of hyphae appears to be common in this species and reference to this character is made by Eidam.

The fungus develops readily from pieces of infected wood placed in moist chambers, and in most cases no great difficulty was experienced in securing pure cultures on various agars by using fragments of the discolored wood as inocula. On several occasions, however, the fungus has failed to develop from such fragments and this may be explained by the fact that microscopical examination of some of the stained wood discloses no hyphae within the tissues.

In eight-day-old Petri-dish cultures using malt agar the aerial growth covered the entire surface. From the under side the central area of the growth in Petri-dishes is of a pomegranate purple color and the outer, more recent, growth area an olive lake color.[10] The growth is more rapid and the discoloration of the substratum is more intense on prune and oatmeal agars than on malt agar.

Both terminal and intercalary chlamydospores are formed in cultures (fig. 2, D.). These spores may be single but more often are in chains

[10] RIDGWAY, Robert. COLOR STANDARDS AND COLOR NOMENCLATURE. 43 p., 53 col. pl. Washington, D. C., 1912.

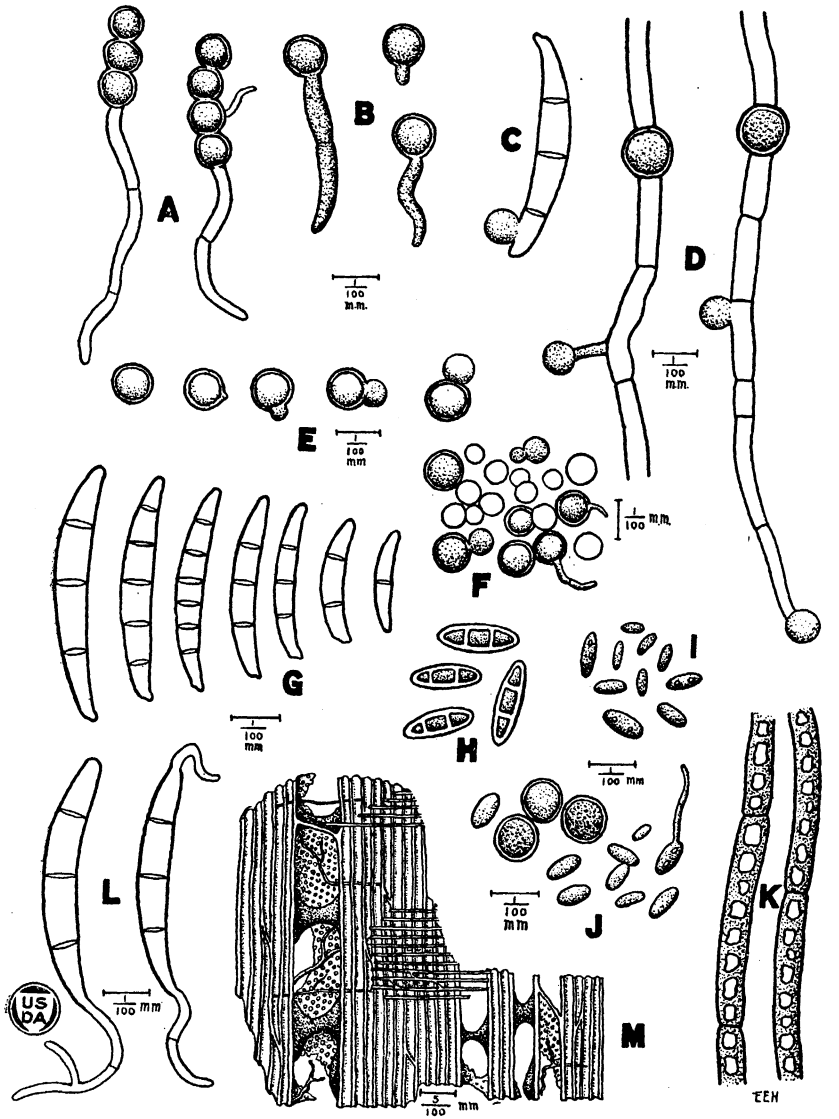

FIG. 2.—A. Chlamydospores in chains, showing germination. B. Chlamydospores, solitary, showing germination. C. Chlamydospore formation from one of the cells of a conidium. D. Various types of chlamydospore formation from partly dried cultures. E. Stages in the budding process of the chlamydospores. F. Chlamydospores taken from débris within a hollow knot, showing variation in size. G. Conidia from culture on oatmeal agar, showing variation in size and septation. H. Purplish colored spores from a dark crust-like layer found in a hollow knot of an infected boxelder. I. Microconidia from hollow knot. J. Chlamydospores with granular contents taken from a sclerotia-like structure (pseudosclerotia) found in culture No. 45, a few microconidia from the same culture. K. Hyphae with red-colored contents and large vacuoles from 60-day old cultures on oatmeal agar. L. Conidia germinating. M. Radial section through red, stained wood, showing hyphae in the tissues and penetration of cell wall.

(fig. 2, A and B.). Under certain conditions chlamydospores are formed from the cells of the macroconidia (fig. 2, C.).

Cover glass cultures, made by using transfers from culture No. 45, when examined under the microscope, showed chlamydospores of the fungus budding and finally germinating (fig. 2, E.). Chlamydospores taken from a reddish crustlike mass inside a hollow knot, when observed in hanging drop cultures, showed a similar budding process, resulting in the formation of large numbers of these spores (fig. 2, F.). Hyaline, one-celled and two-celled microconidia were also present and their germination noted (fig. 2, I.). The older mycelium produced in all these cases showed yellowish to reddish cell contents.

The fungus appears to develop rapidly under very moist conditions. This rapid growth was observed in the artificial inoculation of blocks of fresh sapwood placed in humidity chambers.

Cultural tests using pieces of red-stained boxelder kept in the air-dry condition of a room for a period of one and a half years show that the fungus is capable of reviving at the end of this period. Cover glass cultures made by placing microtome sections of the infected wood on a thin layer of agar under a cover glass showed that the new hyphae at the time of revival may originate from old hyphae or from chlamydospores formed in the tissues. Eidam states:

> In culture in the moist chamber the mycelium grows out from the wood and the brown hyphae put forth young colorless filamentous branches which phosphoresce very beautifully and distinctly so that thereby the whole outline of the piece of wood showed distinctly.

PATHOGENICITY

Numerous isolations of *Fusarium negundi* Sherb. in pure cultures obtained from fragments of the stained wood prove the constant association of this fungus with this particular disease, which is characterized by a reddish discoloration. Comparisons of the hyphae and spores produced in pure cultures with those found in and upon the red-stained wood furnish additional evidence. Conidia (fig. 2, I.) and chlamydospores (fig. 2, F.) resembling closely those produced in pure cultures were found on infected trees in the débris scraped from hollow knots and from cavities in the bark produced by species of sapsuckers. Poured plate dilution cultures made from this spore mass developed colonies of a Fusarium which colored the agar a bright red and which were identified as *Fusarium negundi* Sherb. Information gathered in connection with sapsucker injury, leads to the opinion that the fungus is either weakly parasitic or develops on the injured tissues and produces discoloration of the surrounding sapwood tissues by diffusion of the colored matter which is in solution. By far the greater number of infections so far found in the sapwood of the living tree have their origin in the wounds produced by sapsuckers. (Pl. 2.)

The red stain was produced artificially in the laboratory on boxelder wood by inoculation with the fungus from pure cultures obtained from the red-stained wood. Difficulty was experienced in attaining positive results when heartwood of boxelder was used after sterilization by autoclaving for a period of 45 minutes at 15 pounds pressure. Better results were gained by using fresh sapwood blocks, surface sterilized by washing in mercuric chlorid and distilled water. Table I gives the results of these experiments. The fungus reisolated from a stained spot on one of the blocks was found to be identical with *Fusarium negundi*.

LIFE HISTORY

Not a great deal has been learned of the life history of this fungus. The presence of chlamydospores and conidia in hollow knots, in holes produced by sapsuckers, on the surface of broken branches showing red stain, and on dead wood exposed by wounding, indicates that these spores are produced upon the surface of the host wherever wounding and other factors have afforded suitable conditions. Undoubtedly many of the spores are wind or water borne, but judging from the activities of sapsuckers in connection with this host it is reasonable to suppose that these birds play an important part in disseminating the spores. A glance at Plate 3 will show a number of small red, stained areas in the sapwood between the bark and the continuous red area (dark band) surrounding the decayed heartwood. These areas are seen to be directly associated with "bird peck," a type of injury caused by the sapsucker in search of food. The evidence in Plate 3 shows that the same cavity is used at intervals to tap the cambial layer; in this case three annual rings intervene between two red areas which are directly in line with the hole drilled in the bark by the bird. The most recent injury, apparently produced in the spring of 1922, was not healed at the time the tree was cut in November of the same year. If these deductions are correct, then it is quite possible for the bird to transmit the fungus from one portion of the tree to another or from tree to tree.

The years of greater activity of this bird for a particular area on the tree can be measured by the larger number of bird-peck stain spots occurring along the same annual ring. The smaller spots represent the stained areas above or below the original injury and nidus of infection. The three blocks in Plate 3 show the "bird pecks" in longitudinal section of the wood.

In pure cultures the spores of *Fusarium negundi* Sherb. are produced within a period of three days. Under natural conditions sporulation could easily take place within the hole drilled in the bark by the sapsucker before the callus developed sufficiently to isolate the fungus within the sapwood. The next visit of the bird to the spot would result in a contamination of its bill with these spores.

Wounds caused by wind breakage, by pruning, by fire and by sapsucker attack, appear to be the most common infection courts for the entrance of this fungus. The part which insects may play in the life history of this stain organism has not been investigated.

The organism in the form of hyphae overwinters within the host tissue, renewing its activity upon the return of favorable temperature and moisture conditions.

CONTROL MEASURES

Sanitary measures are probably the only practicable means in controlling this disease on shade trees, providing the fungus is found to cause sufficient damage. Proper care of the trees in respect to the various injuries it suffers will aid greatly in reducing the chances of infection, not only of this disease but of the more serious heartrot and parasitic types. Wounds of all kinds should be given particular attention. Detailed information regarding the proper methods of caring for wounds on shade trees may be found in United States Department of Agriculture Bulletin No. 1178.[11]

[11] COLLINS, J. FRANKLIN. TREE SURGERY. U. S. Dept. Agr., Farmers' Bul. 1178, 32 p., 24 fig. 1922.

TABLE I.—*Results of infection experiments on wood of boxelder with pure cultures of the fungus, Fusarium negundi*

Experiment No.	Date.	Source of inoculum.	Medium and dimensions (inches).	Method of sterilization.	Number of tubes.	Results.	Date of results.
1	Apr. 7, 1921	Culture No. 91.	Blocks of heartwood, 1×1×5.	Autoclaved at 15 lbs. for 45 min.	3	Slight red stain in wood surrounding inoculum. Penetration of stain, slight.	May 9, 1921.
2	Apr. 7, 1921	Culture No. 45.	Blocks of heartwood, 1×1×5.	Autoclaved at 15 lbs. for 45 min.	3	Considerable surface staining of wood where hyphae developed. Penetration of stain, slight.	May 9, 1921.
3	Apr. 8, 1921	Culture No. 45.	Blocks of heartwood, 1×1×5.	Autoclaved at 15 lbs. for 45 min.	2	No staining. Hyphal growth scanty. Myxomycete strands developed from inoculum. Sclerotia-like growths on wood.	Apr. 26, 1921.
4	Apr. 7, 1921	None. Control.	Block of heartwood.	Autoclaved at 15 lbs. for 45 min.	1	No growth. No staining.	May 9, 1921.
5	Dec. 1, 1922	Culture No. 182.	Blocks of fresh sapwood, 1⅛ ×1⅛×2.	Surfaces washed with $HgCl_2$ and with distilled water.	3	Considerable surface staining in vicinity of inoculum. Penetration of stain into wood for a distance of ¼ inch.[a]	Dec. 14, 1922.
6	Dec. 1, 1922	Culture No. 182.	Blocks of fresh sapwood, 1⅛ ×1⅛×2.	Surfaces washed with $HgCl_2$ and with distilled water.	2	Considerable staining of surface and slightly below. Surface of block gives acid reaction.	Dec. 14, 1922.
7	Dec. 1, 1922	None. Control.	Block of fresh sapwood, 1⅛ ×1⅛×4.	Surfaces washed with $HgCl_2$ and with distilled water.	1	No staining. No hyphae of Fusarium developed.	Dec. 14, 1922.

[a] On Dec. 28 a Myxomycete developed and fruited on the surface of one of the blocks.

If it is found desirable to attempt the control of the disease on boxelder trees in the forest and wood lot intensive methods of control will be impracticable. Such sanitary measures as the burning of affected slash and rapid handling of the logs are steps which can be taken to reduce the number of inoculum sources. Rapid removal of the logs to the mill may reduce the production and dispersal of spores and rapid seasoning may check the development of the fungus in the wood.

SUMMARY

A disease of the boxelder characterized by a bright red stain in the wood has been under observation by the writer since 1920. The stain is very frequently met with and, therefore, popularly believed to be a fairly reliable character for the identification of this wood.

The cause of the discoloration ranging from light coral red to hellebore red or carmine in the heartwood and to a less extent in the sapwood is due to the presence in the wood of a soluble red pigment produced by the colored hyphae of a fungus, *Fusarium negundi* Sherb.

The fungus appears to be weakly parasitic since it is found developing in the sapwood following entrance through wounds principally caused by sap-suckers. The latter appear to be agents in the dissemination of the spores from different parts of a tree or from tree to tree. No evidence of penetration through living tissue in the absence of wounds has been noted.

For uses where bright, stain-free stock is required the red-stained wood is rejected. Presence of the stain may degrade the stock and reduce the price per thousand board feet. The association of the red-stain organism with fungi-producing wood rot in the same tree necessitates caution in the use of affected material.

The geographical distribution of the red-stain disease is assumed to coincide with the range of the boxelder. It has been found in many places in the United States, and what appears to be the same disease has been reported in a few places in Europe.

As means of preventing the discoloration of the wood and as a preventive measure in case the organism develops greater parasitic tendencies, sanitary measures directed to the proper care of wounds are suggested for shade trees; and for forest trees the burning of affected slash and the rapid handling of infected logs are believed to be of value.

PLATE 1.

Fusarium negundi Sherb. on oat agar, 56 days old. Hand painted by W. R. Fisher, of Cornell University. Natural size. Colored photograph furnished by Dr. C. D. Sherbakoff.

Journal of Agricultural Research Washington, D. C.

The Red Stain in the Wood of Boxelder

PLATE 2

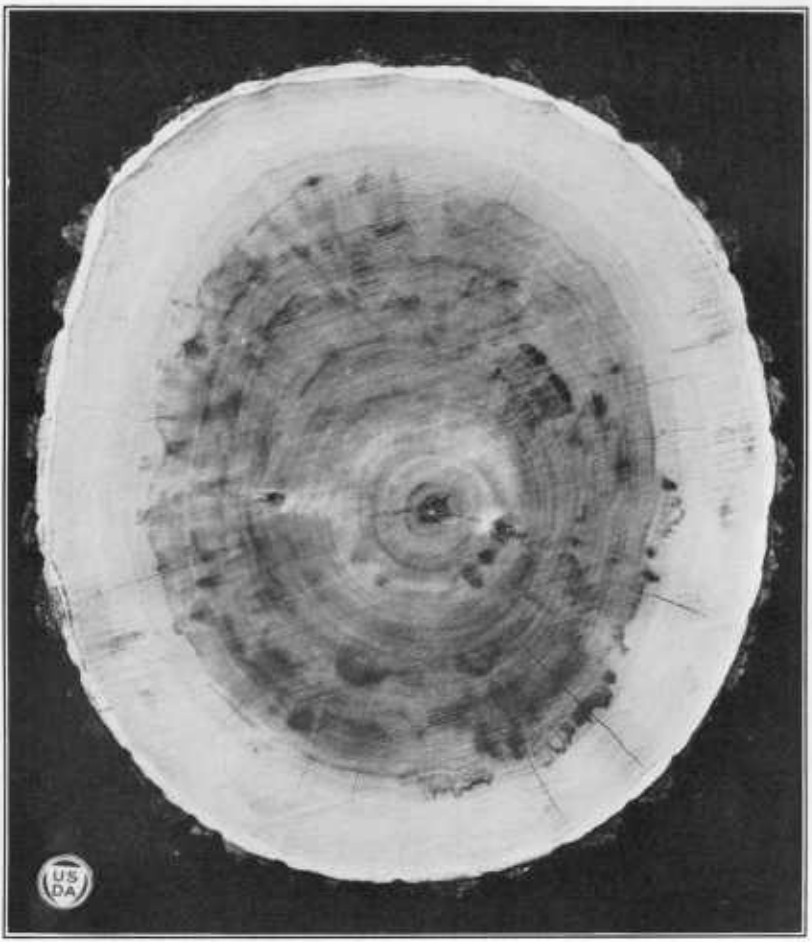

PLATE 2.

Transverse section through the trunk of a boxelder showing the heartwood discolored by the red stain caused by *Fusarium negundi* Sherb.

PLATE 3.

Transverse section of boxelder cut down in November, 1922, showing the heartrot of *Fomes applanatus* in the central heartwood, surrounding this is a dark band of red stain with five projecting areas all halting abruptly on the same annual ring. The sapwood shows scattered individual infections by the red stain fungus which entered through the injuries produced by sapsuckers. At the division line between the two annual rings last formed are found eight of these infections. One of these injuries had not been healed and the direct relation is shown between the red stain area and the cavity in the bark and cambium produced by the bird. Three of the "bird pecks" are shown in longitudinal section of the wood.