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SOME PARASITIC POLYPORACEAE.

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Up to within the past eight or ten years, very little attention had been paid in America to the study of those forms of fungi causing forest diseases. The reasons are obvious. Previously, the occurrence of a few diseased trees was practically unnoticed, due to the vast area of our forests. But, with the advance of the lumberman in the last decade, the situation has changed, and a demand has arisen among all classes of people for a more economical and rational treatment of the existing forest lands. The diseased trees of the primeval forest were ignored, as they were so few in comparison with the sound ones. While now the marked appreciation in the value of timber, cause the timber destroying agencies to become of immediate interest. These silent enemies of the forest are working here and there, not attracting the attention of the casual observer as do the careless habits of the lumberman and the forest fires.

The polypores were formerly supposed not to be of a parasitic nature, and the papers published upon them dealt only with the fruiting portion. While now their parasitic nature is established. The effect brought about through the growth of the fungus, is the important economic question which is considered in the present paper.

The field for work on forest diseases is a large one, and its possibilities are just becoming apparent. Compared with other fields of activity, there are but a few workers, among the more prominent of whom we might name Drs. von Schrenk, Spaulding, Metcalf, Hedgecock, and Professor Atkinson. The government is just beginning to take cognizance of these fungi as producing diseases of forest, nut, and shade trees as is shown by Orton and Ames in Plant Diseases in 1907, where mention of them is made forty-eight times.

In the present paper, I shall present a study of some of the higher fungi of the family Polyporaceæ, and describe the characteristic changes which their mycelia induce in the wood of the trees in which they grow. These fungi were observed in the field causing the decay ascribed to them.

The relation of the fungus to its host is a definite one. The question of the spore gaining its entrance is somewhat problematic. That any here studied gained entrance unaided, I believe is not safe to assert. Few of the fungi can gain an entrance unaided through the living layer of cambium tissue, which envelopes the entire tree, and while uninjured, serves as an effectual barrier against many of these enemies. For their entrance, fungi are usually dependent upon some agencies, usually gaining entrance through mechanical injuries to the host. There must be some condition conducive to infection, either a broken branch, a wound, or lack of vitality. When a tree once becomes diseased, the mycelial threads spread rapidly, filling the heart wood with

holes or changing it to a brittle substance having none of the properties of wood. These changes weaken the trunk, and now it is only a question of time until the tree is broken by the wind.

That some fungi possess great adaptability is shown by Elfvingia megaloma, which attacks both living and dead trees, as well as stumps and logs, showing it to be both parasitic and saprophytic. Pyropolyporus conchatus also has this dual nature. The greater majority of parasitic diseases, however, is induced by a wound. As stated before, in most instances there must be some means for the spore to gain access other than directly through the cambium layer. Hence if it be true that injury is necessary for infection, we might decrease the possibility of attack by care in handling trees to be transplanted, in pruning, and also in protection. The true parasite is not to be found among the specimens under consideration in this paper. Very few wood rotting fungi are capable of entering an uninjured tree. Nearly all gain lodgement in wounds, grow in from these, and rot the wood.

The effect of parasite on the host may remain unnoticed for some time, as the growth is very slow. The first noticeable indication of the presence of a fungus disease is the sporophore. As the age of the fungus increases the greater is the number of sporophores, of which I have seen as many as twenty-five on a single host. When this stage is reached, the effect may be noticed in the dead branches at the top, and pale color of foliage. When the host becomes thus infected it succumbs to the wind by either being broken off or up-rooted.

A microscopic examination of some of these diseases shows that the wood tissues are penetrated by tiny mycelial threads. These threads are seen to attach themselves to the cell walls, and to pierce it in all directions. Thus these tiny threads form a network in the wood, and as they increase in number, they dissolve the walls of the wood cells converting them into food for their own consumption. In some cases it is the woody cell wall alone that is attacked; in other cases they consume the starch found in the cells; but in all cases of decay we find these mycelial threads are responsible for the mischief. These fine threads are the vegetative body of the fungus, the little shelf its fruiting body, on which it produces myriads of tiny spores.

The economic side of the problem is also worthy of our consideration. We find that there are but a very few kind of trees, if any at all, that are not subject to fungus diseases; and that both dead and living trees are attacked. A tree does not lie on the ground any time until it is nearly covered with fungus growth. If one is to realize any value from diseased trees they must be used before they reach the last stage, or before they fall. Some of these diseases affect the heart wood, rendering it useless for lumber, and of little value as fuel. That this problem is of the greatest importance is evidenced by the attitude of the government in studying its character, and trying to determine some means of prevention.

The species discussed in this paper are the most characteristic and common of this region, infesting our chief forest trees. They are *Pyropolyporus igniarius* (L.) Murrill; *Pyropolyporus Everhartii* (Ellii & Gall.) Murrill; *Pyropolyporus fulvus* (Scop.) Murrill; and *Elfvingia megaloma* (Lev.) Murrill.

Pyropolyporus igniarius: The sporophores of this fungus are among the commonest and best known of the largest fungi. The hoof-like shelves of this fungus occur widely distributed throughout the United States on the apple, oak, alder, beech, birch, maple and other species of broad leaved trees. In Plant

Diseases of 1907 by Orton and Ames, it is reported from eight different states from Maine to Montana. The fruit bodies are somewhat hoof-shaped, very hard, the upper surface black, while the fruiting surface is cinnamon brown. They are 4—8 inches long, 2—4 inches broad, ½—5 inches thick, and always occur singly. The hymenium is made up of rounded pores. The upper surface is marked by concentric furrows and ridges which mark off the annual layers. Thus the fungus is perennial.

The location of the sporophore on its host leads us to the question of the conditions favoring the entrance of the fungus. Since the mycelium cannot enter through the living cambium layer of the tree, some means of infection must be provided. These infection areas are provided in a variety of ways. From the location of the sporophore on the poplar at the knot-holes, we conclude that it gains entrance through the dying away of the lower limbs, and nature failing to heal the wound formed. The sporophores found upon butternut, iron-wood, and the apple were each located at a wound. Hence we conclude that the fungus must be a wound parasite. The microscopic spores found lodgement in the wounded area, and when proper moisture was obtained it germinated, sending its hyphæ into the heart wood. After it had received the proper nourishment, a sporophore was formed, and spores produced. The number of sporophores on a host varies from one to twenty-five.

Cross sections of a poplar tree present a very characteristic marking of the wood due to the different stages of decay and the coloration of the wood. The more advanced stages of decay lie at the center, the less advanced at the outer edge. It changes the heart wood to a light yellow color, and a very dark line separates it from the outer area which is a dark brown color from the knot-holes to the center there is the same condition, showing its entrance. Atkinson (3) stated, "that the peculiar discoloration of the wood accompanied the mycelium of this specie of fungus, and might be sufficient to identify the species even where no fruit forms of the fungus were present."

Pyropolyporus igniarius was found in greatest abundance infecting the poplar (Populus grandidentata), in fact, only one specimen was found on each of the apple and iron-wood, while several were found on the butter-nut. The fungus appeared to effect the black poplar more than it did the white; and it appeared to attack no trees less than five inches in diameter. In some groves of poplar the greater per cent of them were infected, while in others it was not so prominent.

The effects are easily to be seen in some localities where a greater number of the trees lie on the ground. From this we might conclude that it effects the tree as a whole, causing its decay and finally its fall. To estimate the possible loss is a difficult task; but as these trees are somewhat limited in quantity in localities we can readily see that the damage is great. If the tree is not used before it falls, the wood is of but little value, and, as far as lumber purposes is concerned it is of no value whatever. This fungus is not so serious as a hard wood disease, for it effects only our less important forest trees.

Poropolyporus Everhartii: This fungus is found to infest the broad leaved woods of this region, the hardiest and best of our timber, the red and white oak. We find this fungus is not as widely distributed over the United States as the former, and is only known on the oak and occasionally on the beech. In Plant Diseases of 1907 it is not reported.

The sporophores are hoof-shaped, very hard, the upper surface a very dark brown, while the fruiting surface is a cinnamon brown. They are 1½—12 inches long, 2—6 inches broad, by 1—6 inches thick and always occur singly. The hymenium is composed of rounded pores. The upper surface is marked by concentric ridges, which correspond to the annual growth. Thus the fungus is perennial, and attains to such an age that the upper surface may be covered with tiny moss plants, also deeply checked. If a sporophore is cut open, each year's growth is definitely marked by a lighter band separating them. This is quite distinct to about half its age, when the remainder is made up of lighter mycelial threads.

The condition favoring the entrance of the spores are through wounds, knot-holes, and cavities made by boring insects. It is from the location of the sporophore on the host, that we are led to determine the means of infection. There is also a greater diversity in the size of hosts of this fungus. It has been found frequently on red oaks of but three inches diameter; and not in connection with a wound or knot, and in most cases the host has been dead. But in the case of the larger trees it has never failed to be located at some wound or knot. In making a cross section of a tree containing one of these sporophores, I found a cavity which had been formed by some boring insect. The fungus being located at this cavity leads us to conclude that it either entered or grew out through this opening. In the light of the paper by Hopkins (8) on the relation of fungi and insect burrows, we must conclude that this species is a wound parasite. Due to these exposed areas the spore gained access through the cambium layer, and germinated, penetrating the heart wood of the tree. After the mycelium had penetrated the host gathering nourishment, a sporophore was formed, which is the only outward sign of disease. The location of these punks on the host varies. It is found on small trees near the ground, while on the larger trees it is observed higher up near a broken limb or wound. It is very seldom there is more than one specimen found on a tree.

A study of a cross section of an oak near one of these sporophores shows that the fungus has destroyed a definite portion of the entire heart wood, changing it to a light brown, pulpish mass. The light and dark wood is not separated by a darker area as in the former, but they are inter-mixed. One noticeable effect is that the medullary rays stand out very firm while the surrounding area is broken up.

The greater abundance of this fungus was found on the red oak, but it is not as common as the former studied. Still I have noticed that it is found but very little among the healthy timber, while among the dwarfed, scrubby jack oaks and the stunted burr-oaks of wind swept hillsides, it is more numerous. From this might we not conclude that the vitality of the tree gave a means of infection. The proportion of trees diseased to those not is very small, in fact much less than in Pyropolyporus igniarius.

The effect, economically, of this fungus is rather difficult to judge, as the extent of the disease is not very great. Although we find it scattered in different localities, yet there is no extensive tracts affected. But as its host is one of our most desirable kinds of woods, the result will be more noticeable later, if its spread is not checked. For each year a sporophore discharges myriads of spores, and some of these are sure of finding access in some tree, consequently the infected areas are increased each year. As no study has been made of a large diseased tree, we only form a conjecture as to its probable condition;

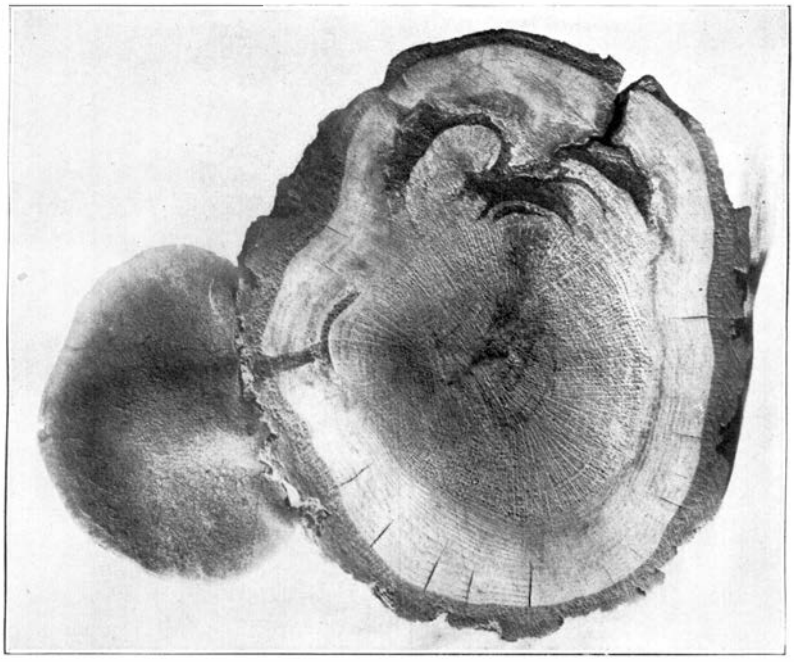

Plate 1.—Fig. 1. Section of living red oak tree (Quercus rubra) near a sporophore of Pyropolyporus Everhartii, showing the decay; also the cavity formed by a boring insect.

Fig. 2. Section of the same tree, six feet above the sporophore, showing the presence of the mycelium also the cavity.

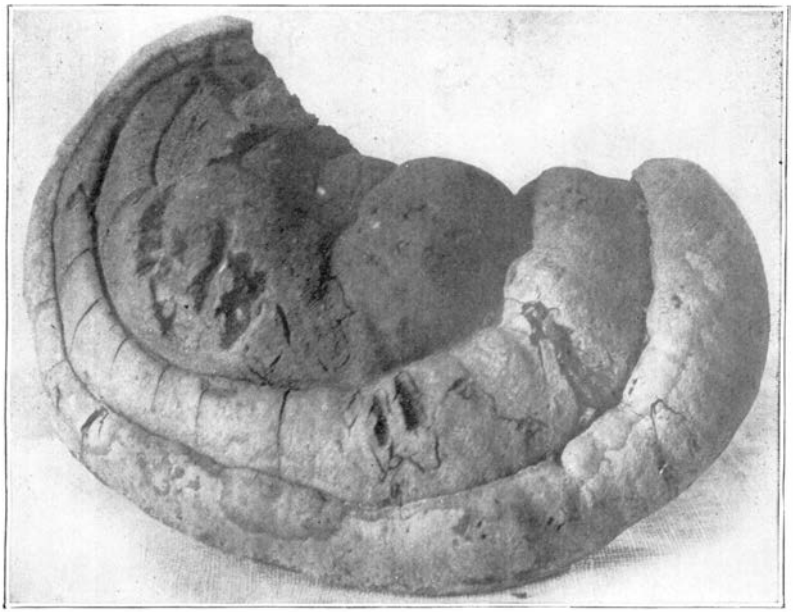

Plate II.—Fig. 1. Fruiting body of Pyropolyporus Everhartii showing the upper surface.

Fig. 2. Fruiting body of Pyropolyporus Everhartii showing the hymenial surface.

but from our knowledge of the effect on small trees, we may conclude that the lumber quality is destroyed, hence an economic loss, as it is being used very extensively for building purposes. For this reason this fungus is one of the most important economically of any of the species under consideration.

Pyropolyporus fulvus: This fungus affects only the diseased trunks of various species of Prunus and is widely distributed over North America and Europe. In Plant Diseases in 1907 it is not mentioned.

The fruiting bodies of this polypore vary in size from 1—6 inches long, ½—2 inches broad, by ¼—1½ inches thick. They form large masses when a large number are joined, as in some instances several limbs or main branches are covered with sporophores. The fruit bodies are elongated usually resupinate, very hard, edges nearly black, while the fruiting surface is a dark brown. This fungus does not grow in shelf form, but horizontal to the tree, leaving the concentric ridges only visible at the very edge of the sporophore; and frequently as resupinate forms coalescing in a series. The hymenium consists of regular pores of rounded minute openings. It is a perennial growth, hence tiny moss plants may be found growing upon it.

The condition favoring spore entrance is a wounded area. It has been observed that the sporophores are more common on the branches than on the trunk, and it has the appearance of working from the top downwards. Upon removing one of these sporophores no wounded area is visible, yet there are some located near a broken limb. Hence we conclude that it was through this broken limb that entrance was gained.

A cross section of a diseased branch shows that it is thoroughly infected, rendering it very brittle, while normally it is tough. Again the alternate area of light and dark wood prevails too near the sap wood. From these noticeable features it appears to attack only definite tissues or else follow the annual growth.

Its favorite host is the wild plum, and a few specimens have been observed on cultivated trees when pruned. One wild grove in particular where specimens were gathered, there was not a tree unaffected and most of them were dead. It appeared also that the cluster in the timber is much more subject to attack than those in the open, which might be explained by the former being more conducive to infection due to more moisture. Also the question arises if the fungus is strictly parasitic, for I believe specimens were gathered on dead hosts. If it be true that a plum supports this fungus long after its destruction, it is more tenacious of life than Pyropolyporus igniarius as the sporophore ceases to grow at the death of the host. Among the plums there is a greater proportion of diseased trees than any other yet studied.

The economic importance of this parasitic disease lies not in the fact of the commercial value of the wild plum, but in the tendency to infect the tame ones. Then it would have an economic importance for the fruit growers.

Elfvingia megaloma: The last fungus for consideration is Elfvingia megaloma, which is widely distributed over the United States and Canada. It is reported from Nebraska by Dr. Heald as parasitic upon cotton wood; likewise by D'Allemend from the same state under the name of *Fomes applanatus* parasitic upon cottonwood. As a parasite it attacks the red oaks in this region, but has not been found on the cottonwood; as a saprophyte it is found on dead trees, stumps and logs.

This fungus is of the bracket form with sporophores varying in size from 2—14 inches long, 1—8 inches wide, by ¾—2 inches thick; it is somewhat hoof-shaped or elongated, very hard, the upper surface dark colored and encrusted, while the fruiting surface is nearly white. The under surface is marked along the edge by an encrusted ridge, and the upper surface is marked by concentric ridges showing that it is perennial. In the popular mind it is associated with etching, because its hymenium changes to a darker color when bruised.

As a parasitic fungus on the red oak its sporophore is found near the ground. The means of infection is not very easily determined, as no wounds have been observed; but as the sporophores are located so near the ground we may conclude that infection is brought about through the roots, or at the base of the trunk near the ground line. This seems quite probable as sufficient moisture is one of the requisites for germination. The fact that it does not attack young trees, but becomes parasitic upon older trees in which the vitality has been lowered leads us to conclude that lack of vitality may be a means of infection. The mycelium spreads upward through the entire wood, and the trunk becomes thoroughly infested before the fungus attains sufficient vigor to produce its external fruiting bodies. The wood is rendered very brittle, and the tree is poorly fitted to withstand the force of wind in severe storms. The trees affected have always been large, probably more than thirty years old. The only evidence of the disease is the presence of a sporophore.

As a parasitic fungus this one is the least numerous of any yet studied. Only two specimens have been found on living trees. But as a saprophyte it is very common, being found on any dead tree, log or stump. But I believe that the log or stump of maple was more infected by it than any other. Dr. Heald (7) says, "Any logs or woods affected with this fungus should be burned as the fungus continues its growth. It seems quite probable that the vegetative mycelium is often the means of infection, rather than the spore direct."

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Plate III.—Fig. 1. Section of living plum tree (Prunus) showing the decay caused by Pyropolyporus fulvus and also the resupinate form of the fungus.

Fig. 2. Shelving forms of Pyropolyporus fulvus as found on a limb.

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