

## NOTES ON APPLE RUSTS.

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The following notes on the apple rusts of Crawfordsville and vicinity are presented with the hope that they may prove helpful to those interested in this group of fungi. The observations recorded here are the results of three years' study of these plants. No systematic classification of our forms has been attempted, but the species studied is probably *Tremella Juniperi-Virginianae* (Schw.), as listed by Arthur in his *Generic Nomenclature of Cedar Apples*. This is the most common one in our locality. Special work on the anatomy of the cedar apple and the various forms in which this fungus occurs is now under way and will be ready for presentation soon.

## GENERAL PREVALENCE OF THE PARASITE THROUGHOUT THIS DISTRICT.

The general prevalence and abundance of this pest throughout this section of the State is to be attributed to two causes: First, the occurrence of cedars throughout the timbered tracts of this region in such numbers and so generally distributed as to insure a universal infection of the orchards of the district; second, the prevailing ignorance of the farmers and apple growers in regard to the relation of the galls of the cedar to the *Roestelia* of the apple. Most farmers have planted cedars about their yards, either for ornament or protection, and as the orchards are always in close proximity to the house, the fungus is placed in a position for easy dissemination and perpetuation. One farmer not far from Crawfordsville alternated a row of apple trees with one of cedars throughout his orchard for protection from winds. Another gentleman, in the city, planted a row of cedars through his orchard along either side of the path that led from the street to his house. The result in both cases, of course, is evident. Almost every lawn in the outskirts of the city supports one or more cedars to the detriment of every susceptible apple tree in the neighborhood.

## PHENOMENAL ABUNDANCE OF THE FUNGUS DURING 1900 AND ITS MARKED SCARCITY THE FOLLOWING SEASON.

The phenomenal abundance of the cedar apples and the very marked ravages of the rust on the apple trees of the city during 1900 aroused the interest not only of those acquainted with the parasite, but also very

generally of the citizens of the city. On a field trip in November, 1899, we noticed the extraordinary abundance and great size of the galls that infested the cedars in yards and pastures. In commenting upon this Prof. Thomas said that never before had he seen them in such numbers and of such large size, some of them being at that time as large as walnuts. The infection was very general. Every cedar from the small seedling to the tall tree was fairly loaded on every twig and branch with the chocolate-brown galls. Just what caused this unusual abundance is not so easily discovered, but perhaps the following record of the weather for July and August and the first days of September, 1899, may throw some light on the matter. From observations made the following year it was found that the aecidiospores began to ripen about July 26. Beginning, then, with July 28, we have the following:

July 28, 1899.....	Rain
August 2, 1899.....	Rain
August 5, 1899.....	Rain
August 8, 1899.....	Rain
August 25, 1899.....	Rain
September 6, 1899.....	Rain

Six heavy rains, followed by intervals of from three to sixteen days of warm, fair weather, as shown by the weather reports kept in the city, the very best conditions for the distribution and germination of the aecidiospores on the cedar. What other factors may have entered into this general infection we are unable to say.

The conditions the following spring (1900) bore out fully the promises of the previous fall. The warm rains of the latter part of April and throughout May brought forth the yellow gelatinous masses of teleutospores in abundance. So numerous and large were the galls that the limbs of the trees bent beneath the burden and the large yellow masses could be seen for long distances. The warm sun of the days following the rain dried up the gelatinous masses, causing the teleutospores to germinate and produce countless numbers of sporidia, which were carried far and near to the apple trees of the city and surrounding country. How perfect the weather conditions of that spring were for the dissemination of this fungus, the following record will show:

April 17, 1900.....	Rain
April 20, 1900.....	Rain
May 6—8, 1900.....	Rain
May 18—19, 1900.....	Rain
May 23, 1900.....	Rain
May 28—29, 1900.....	Rain
May 31, 1900.....	Rain

Here were heavy rains with longer or shorter periods of fair, warm days between them, the thermometer standing on an average at from 68 degrees to 70 degrees F.

Under conditions so favorable to the fungus, infection of the apple trees was very general and the ravages of the *Roestelia* stage of the rust were most severe. Late in July the aecidiospores began to ripen, the leaves of the infected apple trees, already discolored by the numerous yellow spots that had begun to appear during the latter part of May, now grew brown and dropped off, so that by the middle of August some trees were nearly bare and the ground beneath them was covered with dead leaves. Most of the young trees put forth a second growth of leaves. Many of the old trees, seemingly unable to meet the unusual demand, either made a feeble effort or entirely refused to put out new leaves and remained bare until the following spring. Of course, some perished. We recall several such trees that were cut the next summer. The apple crop suffered accordingly. Almost no fruit was produced and the little that did mature was knotty and worthless. While the farmers of the northern part of the State, where cedars are very scarce, were selling apples at fifty cents to one dollar a bushel, grocers in the city of Crawfordsville sold them "three apples for five cents" and proportionately per bushel. This failure of the apple crop of this vicinity, while perhaps due in part to the dry weather of the latter part of July, August and the first of September, was largely because of the ravages of the apple rust. Comparison of this district with other apple producing sections of the country, where the drought was equally severe but where the cedar does not occur, confirms this statement.

The general scarcity of the apple rust the following year (1901) was as striking as had been its general prevalence the previous season. So scarce were the galls in the spring of 1901 that it was with difficulty that we obtained specimens enough to supply a class of nine students. The tree

which the previous year had bent to the ground with its weight of galls now yielded, after careful search, but five or six scrawny specimens. Not only were the galls few in number, they were very small and produced comparatively few spores. In many cases they consisted only of new growths on the sides of the old galls and occasionally even the old galls bore a second crop of teleutospores. To what, then, shall we attribute this marked decrease in gall production? Certainly not to a deficiency in aecidiospore supply, for we have already seen that the supply of aecidiospores during the summer of 1900 was unusually large; not, indeed, to any mishap that may have befallen the galls during the winter of 1900 and 1901, for upon field trips during October and November, 1900, the general scarcity of the galls was very noticeable. The fact remains, then, that the galls were not formed. To us it seems that the cause is to be found in the weather conditions of the latter part of July, August and early September of 1900, the period during which the large crop of aecidiospores was ripened and disseminated and when under favorable conditions very general infection of the cedars should have occurred. The weather reports for the period indicated are as follows:

July 24, 1900.....	Rain
August 12-15, 1900.....	Rain
August 17-18, 1900.....	Rain

Only three rains, practically only two, with long periods of from eighteen to thirty days of warm, dry weather between (there was no rain after August 18 until September 19), with the thermometer averaging about 80 degrees F. A comparison of the above with conditions during the same period in 1899 shows about one-half the number of rains as occurred during the last mentioned time.

The *Roestelia*, while not so abundant during the past summer (1901) as in 1900, have still been plentiful enough to aid materially in the destruction of the remaining apple trees of the city and country. The dry weather of the latter part of the past summer (1901) has had its effect on the infection of the cedars. Galls, while present, are not numerous, and a repetition of the ravages of 1900 are not to be expected. Weather conditions for this period are as follows:

July, 1901, no rain; average temperature, 90 degrees F.
August 14, 1901, rain; average temperature, 80 degrees F.
August 18, 1901, rain; average temperature, 80 degrees F.
September 11, 1901, rain; average temperature, 80 degrees F.

## AN EXPERIMENT.

For the past three years we have had occasion daily to pass the home of Mayor Elmore, of Crawfordsville. On the lawn in front of his house stands a large cedar and just southeast of it, about three rods distant, is a small apple tree, about seven years old. During the spring of 1900 we noticed the great abundance of the cedar apples which infested this cedar and later in the summer the great number of leaves of this apple tree that were covered with the *Roestelia*. That the cedar galls were responsible for the attacks on the apple tree seemed quite evident, but we decided to test it by an experiment the following spring, and also to determine if by exclusion of the spores of the cedar galls the apple tree might not be protected from the ravages of the *Roestelia*. Accordingly on April 24, 1901, one of the limbs of the apple tree was enclosed in a sack of cheesecloth. The apple leaves were just bursting from the buds and the telentospores had as yet not ripened on the cedars. About May 1, just after a hard rain, the first gelatinous stalks with their telentospores made their appearance on the cedar apples, and on the following day sporidia in abundance were produced. On May 27 the first indication of the *Roestelia*, in the form of yellow spots or patches, appeared on the exposed leaves of the tree. Examination of the protected leaves showed only a very few spots. By July 3 no aecidia had ripened, although spermatogonia in abundance had been produced. July 27 the first aecidia matured. The sack had been removed June 25 and the protected leaves showed only about one-half as many spots as the unprotected. No more spots appeared on any of the leaves during the remainder of the season. The last crop of sporidia were produced about the last of May, at least a month before the sack had been removed.

It was also observed that the west side of the apple tree, which was directly exposed to the cedar, bore more clusters of aecidia per leaf than the east side. This fact, together with the results in the protected branch, seems to prove conclusively that the sporidia of the telentospores on the cedar had produced the infection of the apple leaves. The failure of the sack to exclude all of the sporidia was due to their minute size and the openness of the cloth. The experiment will be repeated next spring with cloth of a firmer texture. The fact that infection took place through the cheesecloth proves that the sporidia and not the telentospores are car-

ried to the apple leaves, since the openings in the cloth were too small to allow the latter spores to pass through. This fact seems to have been overlooked in many published reports on this fungus.

#### GERMINATION OF TELEUTOSPORES.

Many attempts at the germination of teleutospores were made in the laboratory. Most of these were more or less successful. The only things brought out worthy of note were: First, that in general our results confirmed the work done by H. M. Richards and recorded in his paper in the *Botanical Gazette* for September, 1889; and second, that best results were obtained when the teleutospores were germinated, not in an abundance of water, but rather on simply moist slides placed in the sunlight under bell jars. This allowed the spores to dry slowly, thus affording natural conditions for sporidia production.

Several gelatinous galls were allowed to dry in the sunlight on the window sill. An abundance of sporidia were produced which covered the sill beneath and about the galls, while wet material showed upon examination no sporidia. This strengthens the statement previously made that the sporidia and not the teleutospores are disseminated by the wind, since evidently the teleutospores never leave the gall before germination.

#### THE GALLS PERENNIAL.

As already mentioned, it was observed that many of the galls of the spring of 1901 were but outgrowths on the sides of old galls and that in many cases these old galls bore a second crop of teleutospores. Although no further investigation has been made, there appears to be but one solution to the problem, and that is that the mycelium had summered in the old galls, producing the new outgrowths and the second crop of spores in the spring. As far as we have found, no record of such a condition has been made, and while evidence seems to show that the mycelium is perennial, we wish to investigate further before making a definite statement and only offer this observation as a matter for consideration by those who may be working on this fungus.

## SUSCEPTIBILITY AND IMMUNITY OF DIFFERENT SPECIES OF APPLES.

Some observations were made in different parts of the city to determine the susceptibility and immunity of different species of apples. In the experiment already described the apple tree infested was of the Milum variety. In the same yard in which this tree stood was another apple tree that was never infected by the rust. It was a fall apple, variety unknown. In another yard in another part of the city stood two apple trees with interlocking branches; one was of the Bellflower variety, a winter apple, the other was a large fall apple, variety unknown. Across the street to the west stood two cedars that usually bore a few galls. The Bellflower always suffered severely from attacks of the pest, while the other tree remained free from it. The difference in the appearance of these two trees by the middle of August was most striking. The Bellflower, with its sickly, yellowish foliage, mottled with the dark clusters of *Roestelia*, presented a striking contrast to the dark, healthy green of its neighbor's. The effect was also very noticeable in the apples of the two trees. Those of the Bellflower were small, knotty and not numerous, although the branches had been loaded with blossoms during the spring. The apples of the other tree were large, perfect and plentiful. More extended observations regarding this point will be made next spring.

The selection of immune varieties seems to be the only solution of the problem of the extinction of the fungus, at least in this vicinity. Not only do cedars occur in the natural forests of the region, but they have been very generally planted by farmers for protection and decoration so that the only other method, the destruction of the cedars, is quite out of the question, as so many not concerned in apple growing would not destroy their cedars, and the absolute destruction of every red cedar would be necessary to exterminate the fungus.

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NOTES ON THE GENUS *STEMONITIS*.

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During the past summer and fall we have made a careful study of the genus *Stemonitis*, as represented by the species occurring in the vicinity of Crawfordsville, Ind. This study has brought out several striking and interesting conditions regarding the development of some structures of this genus. The study was made in the laboratories of Wabash College.