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CONNECTICUT AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

Rust Infection of Leaves in Petri Dishes

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and

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BOTANICAL DEPARTMENT

I stage from *Pinus rigida:* on *Solidago rugosa*, 933, Je. 4, '19, good, II; 1344, Je. 17, '20, excellent, II; 4568, Je. 11, '24, poor, II: on *Solidago sempervirens*, 893, My. 26, '19, poor, II.

II stage from *Solidago rugosa:* on *Aster laevis*, 579, O. 5, '18, failed: on *Solidago rugosa*, 578, O. 5, '18, failed; 1115, O. 27, '19, failed.

II stage from *Solidago* sp.: on *Aster laevis*, 1021, Jl. 19, '19, failed: on *Aster* sp., 1522, O. 28, '20, failed: on *Solidago graminifolia Nuttallii*, 1019, Jl. 19, '19, failed: on *S. rugosa*, 1020, Jl. 19, '19, failed; 1521, O. 28, '20, poor, II: on *Solidago* sp., 1022, Jl. 19, '19, fair, II.

Cronartium Comptoniae Arth.

Successful inoculations on *Myrica asplenifolia* were made with the I stage from the five species of *Pinus* tried. The inoculations with the III stage on the pines probably failed, at least nothing definite showed to the naked eye. Our inoculations of plants in crocks, however, showed that there is very little visible sign of successful inoculation. At one time the *Cronartiums* were classed together under *C. asclepiadeum* but our unsuccessful attempts to inoculate *Ribes* and *Quercus* add weight to the belief that the rusts on these two hosts and *Myrica* are distinct species as now regarded. The details of the inoculations follow:

I stage from *Pinus austriaca:* on *Myrica (Comptonia) asplenifolia*, 4556, My. 28, '24, excellent, II.

I stage from *Pinus montana Mugho:* on *Myrica asplenifolia*, 4285, My. 31, '23, excellent, II; 4566, Je. 10, '24, excellent, II. See Plate XXVIa.

I stage from *Pinus ponderosa:* on *Myrica asplenifolia*, 4286, My. 31, '23, excellent, II.

I stage from *Pinus rigida:* on *Myrica asplenifolia*, 342, Je. 6, '18, good, II: on *Ribes nigrum*, 899, My. 27, '19, failed.

I stage from *Pinus sylvestris:* on *Myrica asplenifolia*, 340, Je. 6, '18, good, II: on *Ribes nigrum*, 302, My. 27, '18, failed: on *R. vulgare*, 301, My. 27, '18, failed: on *Quercus alba*, 341, Je. 6., '18, failed.

III stage from *Myrica asplenifolia:* on *Pinus austriaca*, 1079, S. 15, '19, (?) failed: on *P. sylvestris*, 1078, S. 15, '19, (?) failed.

Cronartium occidentale Hedgc., Beth. & Hunt.

The inoculations with the I stage from *Pinus monophylla* were all made on May 28, 1920 and were successful on the following hosts: *Ribes americanum*, *R. aureum*, *R. aureum chrysococcum*, *R. Cynosbati*, *R. divaricatum*, *R. Grossularia* (*uva-crispa*), *R. hirtellum*, *R. intermedium*, *R. nigrum*, *R. nigrum aconitifolium*, *R. odoratum*, *R. oxyacanthoides*, *R. robustum*, and *Ribes* sps. (cult. gooseberries). Several were apparently new hosts for this rust. The inoculations were in triplicate, the average results being given. We are indebted to Bethel and others of the U. S. Department of Agriculture for the inoculating material used.

I stage from *Pinus monophylla:* on *Ribes alpestre*, 1270, failed: on *R. alpinum* ♂, 1285, failed: on *R. americanum*, 1273, poor, II, III: on *R. aureum*, 1267, good, II, III: on *R. caucasicum*, 1269, failed: on *R. aureum chrysococcum*, 1276, excellent, II: on *R. curvatum*, 1271, failed: on *R. Cynosbati*, 1275, good, II, III: on *R. divaricatum*, 1272, fair, II:

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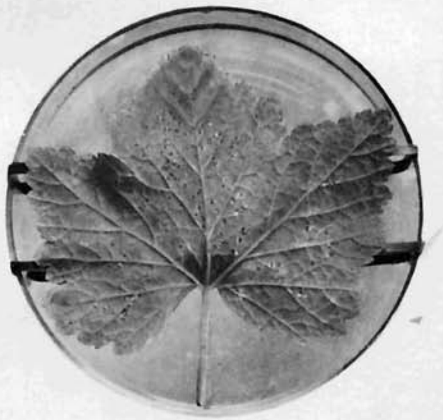
a. II stage of *Phragmidium Potentillae* on *Potentilla canadensis*, Inf. No. 1014a II.

b. III stage of *Gymnoconia interstitialis* on *Rubus villosus*, Inf. No. 959.

c. O stage of *Gymnosporangium Juniperi-virginianae* on *Pyrus Malus*, Inf. No. 937.



d. II stage of *Cronartium ribicola* on *Ribes vulgare*, Inf. No. 764.

ARTIFICIAL INFECTIONS OF RUSTS IN PETRI DISHES.

Rust Infection of Leaves in Petri Dishes.*

G. P. Clinton and Florence A. McCormick.

HISTORICAL.

On May 21, 1918, the writers placed aeciospores (Inf. No. 298) of *Cronartium ribicola* from *Pinus Strobus* on leaves of *Ribes nigrum* in a Petri dish in the hope of determining the method by which the germ tubes entered the leaves. Within twenty-four hours it was found that they had gained entrance into the leaves through the stomates and the dish was set aside for later examination to see if further development took place. About ten days after inoculation examination showed, much to our delight, numerous mature uredinia. Similar inoculations made a day or two later showed about this time even more abundant infections, in fact better than those obtained on living plants.

These results encouraged us in the belief that this method of inoculation might possess advantages superior to that with living plants in the greenhouse; consequently more inoculations were made on a variety of *Ribes* leaves in Petri dishes. Fair success attended these experiments although the inoculating material used was not very good. Improvement of the methods used and comparison of Petri dish versus pot infections, made under similar conditions and at various times, finally led us to the conclusion that the Petri dish method gave results on the whole equal to the pot method and had several distinct advantages in simplicity of operation.

Literature. The writers made brief mention of this method in Bull. 2, White Pine Blister Rust Control, p. 14, published by the American Plant Pest Committee in 1918 and in publications of this Station (Bull. 214, pp. 437, 440, and Bull. 222, p. 471.) in 1919 and 1920.

So far as we know no other writers have published statements concerning successful production of rust sori on leaves in Petri dishes, though somewhat similar experiments have been published by various workers. For instance Farlow (American Acad. Arts & Sci. **20**: 311.) in 1885, working with five species of *Gymnosporangium*, produced pycnia on detached leaves of *Crataegus* and *Amelanchier* with three of the species under the conditions quoted as follows: "The leaves (Pomaceæ) were placed on moistened glass slides and arranged on zinc stands under bell-glasses. The sporidia

* This paper was largely written in the spring of 1921 when other work prevented its completion. It has now been brought up to date including the inoculations made since then. We are indebted to E. M. Stoddard of this department for the photographs used.

were then carefully dropped upon the leaves, which were immediately covered by a bell-glass. The leaves under each glass were sown with the sporidia of but one species, the bell-glasses were removed for a moment only, and at no time were the leaves under more than one bell-glass exposed. I also used a number of small seedlings of Pomaceæ, each pot being covered by a glass receiver."

Ward (Proc. Roy. Soc. Lond. **69**: 451.) in 1902 described a unique method for growing grass seedlings in large special test tubes where pure cultures of rusts were grown on them while thus protected. His method is best described by the following extracts from his paper: "In order to obtain more decisive answers to such questions as—Are any of the results obtained on plants in the open or merely covered with bell-jars and so forth, due to spores accidentally introduced, or to mycelium, etc., already in the plant?—a number of infections were made on seedlings germinated and grown antiseptically in tubes as follows * * * * Clean picked seeds were placed singly, by means of forceps, on filter paper at the bottom of Petri dishes properly sterilized by heat. When these had germinated and observation showed that the whole series was free of moulds or other signs of contaminations, the seedlings were removed by means of sterile forceps, and transplanted singly into sterilized tubes of various kinds as described below, and the further growth allowed to proceed in the light under conditions varied as will be seen * * * * Preliminary experiments soon showed that the Brome seedlings thus raised from seeds treated antiseptically and protected from the first by glass, may be grown for weeks and even for a couple of months in such tubes under proper precautions, and I set myself the task of ascertaining how such cultures would behave in infection experiments. * * * * This experiment is interesting not only as showing that plants can be grown and infected successfully in these closed water-cultures, but especially as showing the contrast between the aerated and non-aerated tubes, for since the infected seedlings were selected in each case from the same Petri dish cultures, we must assume that the difference in rate of development was due to the difference of ventilation, and perhaps conclude that this interferes with the success of the parasite, as measured by the somewhat longer inoculation period. It is remarkable how dwarfed the continuously aerated plants are, compared with those in the closed tubes, owing to the elongation of the leaves of the latter. It is clear, therefore, that pure cultures of Uredo-spores can be obtained by this method, and it is equally clear that we can also obtain pure cultures of the host-plants, and since we can do this, there is no reason why the infection of Uredineae should not be conducted as vigorously and exactly as that of bacteria."

Coons (Ann. Rep. Agr. Exp. Sta. Neb. **25**: 222.) in 1912 made inoculations in Petri dishes with *Gymnosporangium Juniperi-*

virginianae on apple leaves to determine the method of entrance of the germ tubes. Evidently he did not save the inoculations long enough to observe further development. We make the following quotation from his article: "With the microscope it was possible to see the hyphae from the sporidia after a vagrant tortuous growth in the water, bend sharply downward at the edge of the drop and pass into the cells beneath. This last observation was made with leaves washed in sterile water and kept in Petri dishes. These were inoculated in drops of water and marked by circles with the cork borer."

The Petri dish method of infection with fungi other than rusts has been tried by various experimenters as shown by the two following references. Salmon (Journ. Bot. **41**: 212.) in 1903 described his methods with the powdery mildews in these words: "The following method of culture for infection experiments has been adopted. The leaves to be inoculated are cut off from the plant and placed on wet filter paper at the bottom of a Petri dish, the under surface of the leaf being everywhere pressed into contact with the wet filter-paper. If the experiment is to be continued for more than a week or ten days, a seedling with the first leaf attached to the seed must be used. The Petri dishes can be placed in circular dishes of about the same depth and of a half-inch greater diameter and the intervening space at the sides stuffed with cotton-wool. This will remove all danger of infection from foreign spores after the experiment has been set up."

In 1916 very similar methods were used by Blackman and Welsford (Ann. Bot. **30**: 390.) in infection work with *Botrytis cinerea* described as follows: "Before infection the leaves are washed with a gentle stream of sterile distilled water to remove as far as possible extraneous spores and dust. They are then placed on damp filter-paper on a sterile Petri dish, and drops of the prepared solution containing spores placed on their upper surfaces."

The writers were not aware of the methods of the preceding investigators when their work was first undertaken. The results we obtained, however, with *Cronartium ribicola* were such as to justify us in extending the experiments to various other rusts. These experiments have now been carried on over seven seasons. The number of hosts thus infected with various species has exceeded our expectations. The improvement of our methods through experience enabled us to keep leaves alive much longer than at first and thereby successful inoculation was increased. It is deemed advisable to make a more detailed record here of our methods, with the results obtained, in order that they may be used by others, since our experience has shown decided advantages with this method especially with rusts which inhabit the less succulent and ephemeral leaves.

METHODS.

Petri dish versus pot method. Soon after finding that successful inoculation of *Ribes nigrum* could be made in Petri dishes with blister rust, it was decided to carry on a series of tests with different species of *Ribes* in Petri dishes as well as in pots. Tests were made with both I and II stages. In Table I is given a summary of all our experiments with these stages in Petri dishes and pots, regardless of whether they were made under similar conditions or not. This shows that with the I stage out of one hundred and seventy tests made in Petri dishes 66% were successful and according to our grade of marking these were rated poor (+), while of the one hundred and twenty-three tests made in pots 78% were successful with an average of fair (−). These tests favor somewhat the pot method, especially as regards percentage of infection. In this case it is to be remembered, however, that many more leaves were exposed to infection. In the tests with the II stage, where the amount of uredospores and number of leaves inoculated were more nearly alike, because of the difficulty of obtaining an abundance of the spores, the results were about the same. In this case in one hundred and sixty-nine tests in Petri dishes 57% were successful with an average rating of poor (+), while of the fifty-six tests in the pots 57% were successful with an average rating of fair (−).

Several comparative tests were made with the I stage on leaves in Petri dishes and plants in pots, with the other conditions as nearly alike as possible, on twenty-four species and varieties of *Ribes*. While these gave somewhat different results on certain of the hosts, sometimes in favor of the Petri dish and again in favor of the pot, the average result for the lot was about the same from each method, favoring slightly the pot. We concluded at the time, taking into consideration the amount of inoculating material and the number of leaves used, that one method was as successful as the other. We were not able to make similar comparisons with other rusts but our general experience with those inhabiting leaves of shrubs and trees is that the Petri dish method has certain advantages.

Technique. Where a considerable number of inoculations is to be made, Petri dishes of about 100 mm. in diameter and 15 mm. deep are a convenient size to use. A larger size is even more desirable, especially when few are required. Our usual method has been to stretch two well-washed rubber bands loosely across the bottom of the sterilized dish, and on these is placed the wet leaf or leaves. When the cover is inserted the leaves should be near the top but not touching it. Our most recent method has been to file four opposite or equally distant notches, about a quarter of an inch deep, in the edge of the bottom dish and stretch the rubber bands across and diagonally through these to hold the leaves out of the water below but free from pressure above. (See Plate XXVIa.) Glass rods with a flat surface below can be used in place of the rubber bands. These, however, should be of sufficient height to elevate the leaf above the water and near to the cover. A small amount of water is poured in the bottom of the dish. The spores are dusted or brushed off the inoculating material over the exposed surface of the leaf. In case the I and II stages are used it is better to place the lower surface of the leaf uppermost, since infection usually takes place through the stomates which are more abundant on that surface; also the sori that result in such cases usually break out on the lower surface and consequently can be watched carefully without disturbing the leaf or removing the cover. In case the inoculation is with the III stage, where infection generally takes place by direct penetration of the epidermis, it is better to place the upper surface of the leaf uppermost, as this is freer from hairs which hinder infection. Furthermore the pycnial stage is more likely to appear on this surface and it is difficult to carry the infection beyond this stage because of the length of time required. The Petri dish should be placed where it receives direct light favorable for plant growth. North light or direct sunlight partially screened by thin white paper or a coating on the windows is desirable. The conditions upon which infection is successful depend largely upon the following factors—leaves, moisture, light and heat.

Leaves. The leaves must remain in fairly healthy condition from seven to ten days and in some cases more than two weeks after inoculation. Leaves of different plants vary greatly in this respect. As a rule the hardier leaves of shrubs and trees do not succumb as quickly as those of herbaceous plants. Again with some plants, as the grasses, it is often impossible to place the whole leaf in the Petri dish because of its size and mutilation is more or less harmful. Enzymatic or other changes in certain leaves frequently kill them before infection is apparent, but the chief difficulty seems to be with molds that cause decay. This last injury can be reduced or delayed by very thorough washing of both sides of the leaves in running tap water. The wet leaf is then placed in the Petri dish. Partial sterilization did not give so effective results as the washing in water alone. This is a matter, however, that may need further investigation. It is taken for granted that in the selection of leaves only those in the best condition, and, where possible, of a size smaller than the Petri dish will be selected; also that they are free from natural infection.

Moisture. The moisture in the bottom of the Petri dish is sufficient to keep the air fairly well saturated. Considerable moisture becomes condensed on the cover in close proximity to the inoculated surface of the leaf, thereby making conditions for spore germination very favorable. It is necessary from time to time to renew the water in the bottom of the dish as it is lost by evaporation. This may be added by pouring it in the dish or by spraying it over the leaves, as conditions warrant. The dish should never be allowed to become entirely dry as the leaves will wither and die in a very short time. On the other hand the amount of water should not be sufficient to touch the leaf blade in the handling that is necessary. In our work different methods were tried, such as a small film or an abundance of water with the leaf directly on it. The method described, however, seemed to possess the most merits in securing abundance of infection and freedom from molds.

Light. In the first experiments the Petri dishes were left in the diffused light of the culture room some distance from the window. Trouble with molds suggested that better results might be obtained with direct light. Comparative tests were then made both with inoculated and uninoculated leaves left in the culture room and others placed in the small laboratory greenhouse having an eastern exposure but with the light cut off from the south and west. To lessen the strong sunlight of summer the glass was shaded by paper. These tests were in favor of the direct light so that practically all of our infections have been made in this greenhouse. Our opinion is that the latter place is more favorable for the following reasons. First, the direct light on the leaves seems to keep them in healthier condition so that molds are not so troublesome as in subdued light. Second, this action on the chloroplasts favors the normal photosynthetic processes which furnish food for the leaf and thereby favor the more vigorous development of the fungus. If it were not for the ease of examination, etc., it would probably be better in all cases to expose the upper surface of the leaf to the light thereby securing full benefit from it as in nature.

It is surprising how long some leaves remain healthy under these optimum conditions. Not infrequently we have kept leaves green and alive for three or four weeks. In exceptional cases where a callus has formed at the base of the petiole, they have remained alive even longer. In one case a *Rubus* leaf, where a callus had formed and rootlets developed, remained alive for a couple of months. Plate XXVIb shows a black currant leaf about a month after it was placed in a Petri dish developing a secondary callus at one side of the primary one. This leaf was just beginning to die when photographed. Plate XXVId shows one of several leaves of *Solidago rugosa* that remained alive and green three months in the Petri dishes developing from the calluses formed at their bases branched rootlets one to two times the length of the leaves. These leaves were then placed in sand and later earth added in the hope that they might develop buds and new plants and were still healthy and green after four months. Either the addition of the earth or accidental drying out caused their death soon afterward. However, one had formed a minute plantlet on a root or runner developed from the callus. These examples are, of course, exceptional but in case a callus develops longer life is assured. Whether coating the end of the petiole with melted paraffin would favor callus formation has not been determined.

Heat. It has been shown with the rusts, as with other fungi, that spores germinate best at certain temperatures known as their optimum and that maximum temperatures also exist beyond which germination ceases to take place. Doran (Phytopath. **9**: 391–402. S. 1919.) worked with several of the rusts along this line and he found that for the aeciospores of *Cronartium ribicola* the optimum temperature was 12°C and the maximum 19°C and the uredospores had an optimum temperature of two degrees and a maximum of six degrees higher than those of the aeciospores. In our experiments the ordinary room temperature of the greenhouse in spring and fall seemed favorable. In mid-summer, however, the temperature reached such a height that practically all the cultures died out. To obviate this difficulty a modification of Hunt's (Phytopath. **9**: 211–12. My. 1919.) iceless refrigerator was used. This on the whole kept the temperature down on an average only a few degrees, but it was sufficient to favor the cultures over those outside. However, the cloth cut down the light so that this was not so favorable. A cold incubator with glass sides which can be kept in the sunlight at a desired temperature would be a very valuable adjunct for summer inoculations.

GENERAL RESULTS.

Advantages and disadvantages of method. We will first mention the one disadvantage of the Petri dish method, the early death of the leaves. This happens more quickly with some leaves than with others as has already been mentioned. With *Cronartium ribicola* on *Ribes* it was only an occasional disadvantage as most of the leaves lived long enough to produce mature sori of uredinial and occasionally of telial stages. With such tender leaves as clovers, however, death of the leaves often occurred too early to secure definite results. With *Pyrus* the leaves usually lived long enough to secure pycnia but not long enough to produce aecia. A combination of this method with Ward's, using the latter for grasses and quick growing seedlings, will probably solve the problem for infection of most hosts. No doubt some may be disappointed with their first results of the Petri dish method, as experience is an important factor in obtaining success.

The advantages must be evident to anyone who stops to consider the matter. First, we mention compactness. Petri dishes occupy little space and by means of glass or wire shelves many can be used in a small area. Ordinarily we have used them on glass shelves in the iceless refrigerator or on a cement greenhouse bench containing sand which has been covered with botanical driers soaked in corrosive sublimate to prevent molding. The second advantage is economy of material. Often one plant will furnish enough leaves for many experiments whereas if the pot method is used the whole plant is involved. A third advantage is ease and exactness of observation. With a leafy plant of some size the first appearance of the sori may escape observation. These can be observed through the Petri dish cover very easily and quickly. By this method we have found uredinial sori within six days and twenty-two hours after inoculation. This is earlier than we have ever found them on plants in pots. A fourth advantage is the surety of pure cultures since there is little danger, compared with plants in pots, of spores of other rusts reaching the inoculated leaves. Better control of moisture for securing germination of spores is another advantage.

Rusts used in the experiments. Altogether thirteen different genera of rusts were experimented with, as follows: *Caeoma, Coleosporium, Cronartium, Gymnoconia, Gymnosporangium, Kuehneola, Melampsora, Melampsoridium, Melampsoropsis, Phragmidium, Puccinia, Pucciniastrum* and *Uromyces*. We were successful in producing one or more infections with all of these excepting the first. Under these genera forty-five different species were used and successful inoculations were secured with all but seventeen. Many different hosts were inoculated with these. Some of these failures were due to the use of the wrong host. In other cases failure was due to poor inoculating material. It is quite probable that in some tests the leaves died before the sori had time to develop. The most extended experiments were with *Cronartium ribicola* involving three hundred and thirty-nine tests on thirty-eight different species and varieties. Tests were made with all spore stages, O, I, II and III. No results were obtained with the O stage, as was to be expected. Most inoculations were made with the I and II stages. No new relationships between supposedly distinct species were found. Several new hosts, however, were secured through inoculations and a few old hosts are reported for the first time experimentally.

In interpreting the results of the inoculations we have used the following terms: failed, poor, fair, good and excellent. These, except the first, have been used in a general rather than in an exact sense. Usually the number of sori occurring has indicated the class. With the pot experiments, however, the number of infected leaves as well as the number of sori was taken into consideration. The amount of inoculating material used, especially the II stage, was also a factor in grading. As a rule poor indicates that fewer than five sori developed. Excellent implies the development of forty or more on a leaf or leaves in a Petri dish and an even greater total number on the leaves of a plant in a pot. Good and fair are intermediate terms. The inoculation number and date, as well as source of inoculating material and host inoculated, are given with each experiment. The details of the experiments both successful and unsuccessful are given in the following pages.

DETAILS OF INOCULATIONS AND INFECTIONS.

Caeoma nitens Schw.

None of the inoculations made with this short cycled form was successful. Comparison should be made with similar successful inoculations with the long cycled form given here under *Gymnoconia interstitialis.* We thought at one time that possibly this short cycled form was the *Caeoma* stage of some other rust, most likely *Melampsora*, but our failures to inoculate the various species of *Populus*, *Salix* and *Betula* discredit this supposition. Likewise the failure to inoculate mature leaves of *Rubus* species has led us finally to believe that infection takes place with this short cycled form only through the young tissues especially the underground shoots. See articles in Bull. 222, p. 469, of this Station.

O stage from *Rubus villosus* (*R. canadensis*): on *R. villosus*, 894 (upper surface), 895 (lower surface), 896 (cut surface), My. 27, '19, failed.

I stage from *Rubus allegheniensis* (*R. villosus*): on *R. allegheniensis*, 1349 (wild), 1353 (Erie), 1355 (Snyder), Je. 22, '20, failed: on *R. villosus*, 1347, Je. 22, '20, failed: on *R. occidentalis*, 1345, 1351, Je. 22, '20, failed.

I stage from *Rubus villosus:* on *Betula lenta*, 904, 911, 918, My. 27, '19, failed: on *B. populifolia*, 903, 910, 917, My. 27, '19, failed: on *Populus deltoides*, 907, 914, 921, My. 27, '19, failed: on *P. grandidentata*, 901, 908, 915, My. 27, '19, failed: on *P. tremuloides*, 902, 909, 916, My. 27, '19, failed: on *Populus* sp., 363, Je. 22, '18, failed: on *Rubus hispidus*, 4336, Je. 15, '23, failed; 4351, Je. 20, '23, failed: on *R. villosus*, 332, 333, 334, 335, Je. 6, '18, failed; 958, Je. 11, '19, failed; 4004, Je. 15, '22, failed; 4289, 4292, Je. 1, '23, failed; 4327, Je. 12, '23, failed; 4337, Je. 15, '23, failed; 4344, Je. 16, '23, failed; 4349, Je. 20, '23, failed; 4579, 4582, Jl. 2, '24, failed: on *Rubus* sp. (cult. blackberry), 4007, Je. 15, '22, failed; 4288, 4291, Je. 1, '23, failed; 4328, Je. 12, '23, failed; 4350, Je. 20, '23, failed; on *Rubus* sps., (wild and cult. raspberry), 4005, 4006, Je. 15, '22, failed; 4290, 4293, Je. 1, '23, failed: on *Salix* sps., 905, 906, 912, 913, 919, 920, My. 27, '19, failed.

Coleosporium delicatulum (Arth. & Kern) Hedgc. & Long.

The successful inoculation, on *Solidago graminifolia Nuttallii*, was with the host on which the II and III stages of this rust most commonly occur in this state. The senior writer in years previous had also inoculated the same host in crock experiments. One out of four inoculations was successful as follows:

I stage from *Pinus rigida:* on *Aster* sps., 807, 808, My. 19, '19, failed: on *Solidago graminifolia Nuttallii*, 814, My. 20, '19, fair, II: on *S. rugosa*, 806, My. 19, '19, failed.

Coleosporium Solidaginis (Schw.) Thuem.

Inoculations of the I stage from *Pinus rigida* were successful on *Solidago rugosa*, *S. sempervirens*, and of the II stage from *Solidago* sp. on *Solidago* sp. and *S. rugosa.* Five out of twelve inoculations, or 42%, were successful as follows:

I stage from *Pinus rigida:* on *Solidago rugosa*, 933, Je. 4, '19, good, II; 1344, Je. 17, '20, excellent, II; 4568, Je. 11, '24, poor, II: on *Solidago sempervirens*, 893, My. 26, '19, poor, II.

II stage from *Solidago rugosa:* on *Aster laevis*, 579, O. 5, '18, failed: on *Solidago rugosa*, 578, O. 5, '18, failed; 1115, O. 27, '19, failed.

II stage from *Solidago* sp.: on *Aster laevis*, 1021, Jl. 19, '19, failed: on *Aster* sp., 1522, O. 28, '20, failed: on *Solidago graminifolia Nuttallii*, 1019, Jl. 19, '19, failed: on *S. rugosa*, 1020, Jl. 19, '19, failed; 1521, O. 28, '20, poor, II: on *Solidago* sp., 1022, Jl. 19, '19, fair, II.

Cronartium Comptoniae Arth.

Successful inoculations on *Myrica asplenifolia* were made with the I stage from the five species of *Pinus* tried. The inoculations with the III stage on the pines probably failed, at least nothing definite showed to the naked eye. Our inoculations of plants in crocks, however, showed that there is very little visible sign of successful inoculation. At one time the *Cronartiums* were classed together under *C. asclepiadeum* but our unsuccessful attempts to inoculate *Ribes* and *Quercus* add weight to the belief that the rusts on these two hosts and *Myrica* are distinct species as now regarded. The details of the inoculations follow:

I stage from *Pinus austriaca:* on *Myrica (Comptonia) asplenifolia*, 4556, My. 28, '24, excellent, II.

I stage from *Pinus montana Mugho:* on *Myrica asplenifolia*, 4285, My. 31, '23, excellent, II; 4566, Je. 10, '24, excellent, II. See Plate XXVIa.

I stage from *Pinus ponderosa:* on *Myrica asplenifolia*, 4286, My. 31, '23, excellent, II.

I stage from *Pinus rigida:* on *Myrica asplenifolia*, 342, Je. 6, '18, good, II: on *Ribes nigrum*, 899, My. 27, '19, failed.

I stage from *Pinus sylvestris:* on *Myrica asplenifolia*, 340, Je. 6, '18, good, II: on *Ribes nigrum*, 302, My. 27, '18, failed: on *R. vulgare*, 301, My. 27, '18, failed: on *Quercus alba*, 341, Je. 6., '18, failed.

III stage from *Myrica asplenifolia:* on *Pinus austriaca*, 1079, S. 15, '19, (?) failed: on *P. sylvestris*, 1078, S. 15, '19, (?) failed.

Cronartium occidentale Hedgc., Beth. & Hunt.

The inoculations with the I stage from *Pinus monophylla* were all made on May 28, 1920 and were successful on the following hosts: *Ribes americanum*, *R. aureum*, *R. aureum chrysococcum*, *R. Cynosbati*, *R. divaricatum*, *R. Grossularia* (*uva-crispa*), *R. hirtellum*, *R. intermedium*, *R. nigrum*,. *R. nigrum aconitifolium*, *R. odoratum*, *R. oxyacanthoides*, *R. robustum*, and *Ribes* sps. (cult. gooseberries). Several were apparently new hosts for this rust. The inoculations were in triplicate, the average results being given. We are indebted to Bethel and others of the U. S. Department of Agriculture for the inoculating material used.

I stage from *Pinus monophylla:* on *Ribes alpestre*, 1270, failed: on *R, alpinum* ♂, 1285, failed: on *R. americanum*, 1273, poor, II, III: on *R. aureum*, 1267, good, II, III: on *R. caucasicum*, 1269, failed: on *R. aureum chrysococcum*, 1276, excellent, II: on *R. curvatum*, 1271, failed: on *R. Cynosbati*, 1275, good, II, III: on *R. divaricatum*, 1272, fair, II:

on *R. Grossularia (uva-crispa)*, 1289, fair, II, III: on *R. giraldii*, 1268, failed: on *R. hirtellum*, 1281, fair, II: on *R. holosericeum*, 1284, failed: on *R. intermedium*, 1278, fair, III: on *R. luridum*, 1280, failed: on *R. nigrum*, 1279, poor, II: on *R. nigrum aconitifolium*, 1287, poor, II: on *R. odoratum*, 1290, good, II: on *R. oxyacanthoides*, 1291, good, II, III: on *R. robustum*, 1277, poor, II: on *R. stenocarpum*, 1288, failed: on *R. vulgare* (Fay's Prolific), 1274, failed; 1283 (small currant), failed; 1282, (white currant), failed: *Ribes* sps. (large cult. gooseberry), 1286, poor, II; 1292 (Smith's small gooseberry), poor, II, III.

II stage from *Ribes aureum chrysococcum* (in Petri dish): on *Ribes aureum chrysococcum*, 1276 (2), Je. 17, '20, failed.

II stage from *Ribes gracillimum*: on *R. americanum*, 4403, Jl. 14, '23, failed: on *R. aureum*, 4404, Jl. 14, '23, failed: on *R. nigrum*, 4402, Jl. 14, '23, failed.

Cronartium ribicola Fisch. de Waldh.

Inoculations with I stage from *Pinus Strobus*. In the experiments with the I stage thirty-eight species and varieties of *Ribes* were used and one hundred and seventy-two inoculations made. Of these one hundred and six, or 62%, were successful, despite using old spores and inoculating the upper surface in a number of cases. *Ribes nigrum*, with twenty-seven tests of which nearly 78% produced infection, and *Ribes oxyacanthoides*, with eight inoculations and 87% of infection, gave the best results. The following species also became infected: *R. alpinum* ♀, *R. americanum*, *R. aureum*, *R. aureum chrysococcum*, *R. caucasicum*, *R. Cynosbati*, *R. Cynosbati inerme*, *R. diacantha*, *R. divaricatum*, *R. fasciculatum chinense*, *R. Grossularia (uva-crispa)*, *R. hirtellum*, *R. holosericeum*, *R. intermedium*, *R. longiflorum*, *R. luridum*, *R. nigrum aconitifolium*, *R. odoratum*, *R. robustum*, *R. vulgare*, *R. vulgare* (Fay's Prolific), *R. vulgare* (Small Currant), *R. vulgare* (White Currant), *Ribes* sp. (large gooseberry) and *Ribes* sp. (Smith's Small gooseberry). We are indebted to the Arnold Arboretum for most of the species of *Ribes* used in these and the other inoculations.

Uniform failure to infect leaves when spores were placed on the upper surface, where there are few or no stomates, proves infection takes place only through these, as is also shown by actual observation. It is interesting, also, to note that good infection took place with spores 35 days old and poor with those 49 days old (*i. e.*, that long after the branches containing the aecial spores were cut from the tree and left in the laboratory.)

I stage from *Pinus Strobus:* on *Ribes alpestre*, 685, Ap. 28, '19, failed; 787, My. 13, '19, failed; 1313, My. 29, '20, failed: on *R. alpinum* ♀, 687, Ap. 28, '19, failed; 792, My. 13, '19, poor, II, III: on *R. alpinum* ♂, 312, Je. 4, '18, failed; 777, My. 13, '19, failed; 886, My. 22, '19, failed; 929, Je. 4, '19, failed; 1294, My. 29, '20, failed: on *R. americanum*, 304, 309, Je. 4, '18, poor, II; 707, Ap. 28, '19, fair, II; 715, Ap. 28, '19, good, II; 726, My. 2, '19, failed (upper surface); 762, My. 13, '19, failed; 783, My. 13, '19, fair, II; 1315, My. 29, '20, poor, II; 1331, Je. 3, '20, failed?: on *R. aureum*, 313, Je. 4, '18, failed; 671, Ap. 28, '19, failed; 725, My. 2, '19, failed (upper surface); 779, My. 13, '19, failed; 1319, My. 29, '20, fair, II: on *R. aureum chrysococcum*, 305, Je. 4, '18, poor, II; 778, My. 13, '19, fair, II; 888, My. 22, '19, failed; 932, Je. 4, '19, failed; 1305, My. 29, '20, fair, II: on *R. caucasicum*, 306, Je. 4, '18, fair, II; 697, Ap. 28, '19, fair, II; 782, My. 13, '19, fair, II; 1314, My. 29, '20, poor, II: on *R. curvatum*, 786, My. 13, '19, failed; 885, My. 22, '19, failed; 1301, My. 29, '20, failed: on *R. Cynosbati*, 789, My. 13, '19, fair, II; 1317, My. 29, '20, good, II: on *R. Cynosbati inerme*, 770, My. 13, '19, fair, II: on *R. diacantha*, 689, Ap. 28, '19, fair, II: on *R. divaricatum*, 324, Je. 4, '18, fair, II; 679, Ap. 28, '19, good, II; 727, My. 2, '19, failed (inoc. on upper surface); 758, My. 13, '19, fair, II; 1306, My. 29, '20, fair, II: on *R. fasciculatum chinense*, 699, Ap. 28, '19, fair, II; 795, My. 13, '19, poor, II: on *R. Grossularia*, 303, Je. 4, '18, failed; 693, Ap. 28, '19, failed: on *R. Grossularia* (*uva-crispa*), 772, My. 13, '19, fair, II; 1296, My. 29, '20, fair, II: on *R. giraldii*, 695, Ap. 28, '19, failed; 729, My. 2, '19, failed (inoc. on upper surface); 785, 791, My. 13, '19, failed; 887, My. 22, '19, failed; 1310, My. 29, '20, failed: on *R. hirtellum*, 327, Je. 4, '18, poor, II; 701, Ap. 28, '19, fair, II; 730, My. 2, '19, failed (inoc. on upper surface); 1293, My. 31, '20, fair, II: on *R. holosericeum*, 321, Je. 4, '18, poor, II; 1318, My. 29, '20, fair, II: on *R. intermedium*, 325, Je. 4, '18, failed; 717, Ap. 28, '19, good, II; 732, My. 2, '19, failed (inoc. on upper surface); 760 My. 13, '19, fair, II; 1312, My. 29, '20, fair, II: on *R. longiflorum*, 316, Je. 4, '18, poor, II: on *R. luridum*, 691, Ap. 28, '19, good, II; 731, My. 2, '19, failed (inoc. on upper surface); 756, My. 13, '19, fair, II; 784, My. 13, '19, failed; 1308, My. 29, '20, fair, II: on *R. multiflorum*, 311, Je. 4, '18, failed: on *R. nigrum*, 298, My. 21, '18, good, II; 317, Je. 4, '18, poor, II; 328, Je. 3, '18, good, II; 330, Je. 5, '18, good, II, III; 345, My. 23-4, '18, good, II; 350, Je. 12, '18, failed (spores 43 days old); 351, Je. 12, '18, failed (spores 39 days old); 352, Je. 12, '18, good, II (spores 35 days old); 365, Je. 26, '18, poor, II (spores 49 days old); 368, Jl. 23, '18, failed (spores 76 days old); 644, N. 26, '18, poor, II; 658, Ap. 10, '19, good, II; 661, Ap. 12, '19, fair, II; 670, Ap. 21. '19, excellent, II; 674, Ap. 28, '19, good, II; 683, Ap. 28, '19, excellent, II; 734, My. 2, '19, failed (inoc. on upper surface); 741, My. 2, '19, excellent (inoc. on lower surface); 781, My. 13, '19, fair, II; 891, My. 23, '19, failed (spores left 45 days in Petri dish); 892, My. 23, '19, failed (spores 45 days old); 1304, My. 29, '20, fair, II; 4008, Je. 15, '22, fair, II: on *R. nigrum aconitifolium*, 930, Je. 4, '19, failed; 1302, My. 29, '20, fair, II: on *R. odoratum*, 1300, My. 29, '20, good, II: on *R. orientale*, 319, Je. 4, '18, failed: on *R. oxyacanthoides*, 326, Je. 4, '18, good, II; 673, 719, Ap. 28, '19, excellent, II; 740, My. 2, '19, failed (inoc. on upper surface); 780, My. 13, '19, fair, II; 1299, My. 29, '20, fair, II: on *R. pinetorum*, 315, Je. 4, '18, failed: on *R. robustum*, 711, Ap. 28, '19, poor, II; 775, My. 13, '19, failed; 931, Je. 4, '19, good, II; 1316, My. 29, '20, fair, II; 1332, Je. 3, '20, failed?: on *R. stenocarpum*, 314, Je. 4, '18, failed; 776, My. 13, '19, failed; 1298, My. 29, '20, failed: on *P. tenue*, 709, Ap. 28, '19, failed; 737, My. 2, '19, failed (inoc. on upper surface); 768, My. 13, '19, failed; 1295, My. 29, '20, failed: on *R. urceolatum*, 310, Je. 4, '18, failed: on *R. vulgare*, 320, Je. 4, '18, fair, II; 677, Ap. 28, '19, good, II; 738, My. 2, '19, failed (inoc. on upper surface): on *R. vulgare* (Fay's Prolific), 308, Je. 4, '18, fair, II; 657, Ap. 10, '19, fair, II; 660, Ap. 12, '19, fair, II; 672, Ap. 28, '19, good, II; 713, Ap. 28, '19, poor, II; 728, My. 2, '19, failed (inoc. on upper surface); 764, My. 13, '19, good, II; 1307, My. 29, '20, poor, II: on *R. vulgare* (small currant), 318, Je. 4, '18, fair, II; 705, Ap. 28, '19, fair, II; 735, My. 2, '19, poor (1 sorus, II; prob. accidental, inoc. on upper surface); 1309, My. 29, '20, poor, II: on *R. vulgare* (white currant), 307, Je. 4, '18, fair, II; 721, Ap. 28, '19, good, II; 739, My. 2, '19, failed (inoc. on upper surface); 1311, My. 29, '20, fair, II: on *Ribes* sp. (large gooseberry), 323, Je. 4, '18, good, II; 675, Ap. 28, '19, poor, II; 681, Ap. 28, '19, failed; 733, My. 2, '19, failed (inoc. on upper surface); 774, My. 13, '19, failed; 1303, My. 29, '20, failed: on *Ribes* sp. (Smith's small gooseberry), 322, Je. 4, '18, poor, II; 703, Ap. 28, '19, fair, II; 736, My. 2, '19, failed (inoc. on upper surface); 766, My. 13, '19, failed; 1297, My. 29, '20, failed. See Plate XXVd.

Inoculations with I and repeating with II stage. These inoculations all started with the I spores from *Pinus Strobus* on the various species of *Ribes* and then were repeated on the same species of *Ribes* through the II spores produced in the successive generations. In this way we were able to produce from one to nine distinct generations on the different hosts. The most successful host for inoculation was *Ribes nigrum* on which in the best test were produced one generation from the I spores and eight generations from the II spores before failure resulted on account of the very warm summer weather. In this series the III stage appeared with the II in the seventh generation. We know of no one who has carried on so extended a generation test under such exact conditions. Other hosts on which the rust was carried for five or more generations were *Ribes Cynosbati* and *R. vulgare*.

I, II stages on *Ribes alpinum* ♀: I stage on 792 (1), My. 13, '19, poor, II, III; II on 792 (2), Je. 5, good, II, III.

I, II stages on *R. americanum*: I stage on 707 (1), Ap. 28, '19, good, II; II on 707 (2), My. 12, failed. I on 715 (1), Ap. 28, '19, fair, II; II on 715 (2), My. 12, poor, II; II on 715 (3), Je. 5, failed.

I, II stages on *R. Cynosbati*: I stage on 789 (1), My. 13, '19, fair, II; II on 789 (2), Je. 5, poor, II; II on 789 (3), Je. 23, poor, II; II on 789 (4), Jl. 15, poor, II; II on 789 (5), Jl. 25 and Au. 5, poor, II; II on 789 (6), Au. 13, failed.

I, II stages on *R. fasciculatum chinense*: I stage on 699 (1), Ap. 28, '19, fair, II; II on 699 (2), My. 12, poor, II; II on 699 (3), Je. 5, poor, II.

I, II stages on *R. hirtellum:* I on 701 (1), Ap. 28, '19, fair, II; II on 701 (2), My. 12, failed.

I, II stages on *R. intermedium:* I stage on 717 (1) ,Ap. 28, '19, fair, II; II on 717 (2), My. 14, poor, II; II on 717 (3), Je. 5, failed.

I, II stages on *R. luridum:* I stage on 691 (1), Ap. 28, '19, good, II; II on 691 (2), My. 12, poor, II; II on 691 (3), Je. 5, fair, II.

I, II stages on *R. nigrum:* I stage on 658 (1), Ap. 10, '19, good, II; II on 658 (2), Ap. 25 and My. 3, fair, II; II on 568 (3), My. 9 and 12, poor, II; II on 568 (4), Je. 4 and 23, failed. I stage on 661 (1), Ap. 12, '19, good, II; II on 661 (2), Ap. 25 and My. 3, good, II; II on 661 (3), My. 12–13, good, II; II on 661 (4), My. 24 and 28, good, II; II on 661 (5), Je. 10 and 16, good, II; II on 661 (6), Je. 20 and 23, fair, II; II on 661 (7), Jl. 14, 18 and 25, poor, II and III; II on 661 (8), Jl. 25, 28 and Au. 5, poor, II; II on 661 (9), Au. 13 and 26, fair, II, III; II on 661 (10), Au. 26, failed. I stage on 670 (1), Ap. 21, '19, excellent, II; II on 670 (2), My. 1, excellent, II; II on 670 (3), My. 12, good, II; II on 670 (4), My. 28, good, II; II on 670 (5), Je. 10, 16, good, II; II on 670 (6), Je. 20 and 23, fair, II; II on 670 (7), Jl. 23, 28, Au. 4, poor, II; II on 670 (8), Au. 26, poor, II. I stage on 674 (1), Ap. 28, '19, good, II; II on 674 (2), My. 12, fair, II; II on 674 (3), Je. 5, failed. I stage on 997 (1), Je. 16, '19, excellent, II; II on 997 (2), Jl. 12, fair, II, III; II on 997 (3), Jl. 24, 28, 30, fair, II; II on 997 (4), Au. 5 and 13, poor, II.

I, II stages on *R. oxyacanthoides:* I stage on 673 (1), Ap. 28, '19, excellent, II; II on 673 (2), My. 12, failed. I stage on 719 (1), Ap. 28, '19, excellent, II; II on 719 (2), My. 12, good, II; II on 719 (3), Je. 5 and 23, failed.

I, II stages on *R. robustum:* I stage on 931 (1), Je. 4, '19, good, II; II on 931 (2), Je. 23, poor, II; II on 931 (3), Jl. 15, 18 and 21, poor, II; II on 931 (4), Au. 1, failed.

I, II stages on *R. vulgare:* I stage on 657 (1), Ap. 10, '19, fair, II; II on 657 (2), Ap. 23, My. 3, poor, II; II on 657 (3), My. 9 and 13, poor, II;

II on 657 (4), My. 22, poor, II; II on 657 (5), Je. 5, poor, II; II on 657 (6), Jl. 15, failed. I stage on 660 (1), Ap. 12, '19, fair, II; II on 660 (2), Ap. 25, My. 3, fair, II; II on 660 (3), My. 9 and 13, poor, II; II on 660 (4), My. 21, failed.

I, II stages on *R. vulgare* (Fay's Prolific): I on 672 (1), Ap. 28, '19, good, II; II on 672 (2), My. 12, failed.

I, II stages on *R. vulgare* (small currant): I stage on 705 (1), Ap. 28, '19, fair, II; II on 705 (2), My. 12, poor, II; II on 705 (3), Je. 5, failed.

I, II stages on *R. vulgare* (white currant): I stage on 721 (1), Ap. 28, '19, good, II; II on 721 (2), My. 12, failed.

I, II stages on *Ribes* sp. (large gooseberry): I stage on 675 (1), Ap. 28, '19, poor, II; II on 675 (2), My. 12, failed.

Inoculations with II stage from *Ribes nigrum.* In this series the II spores were all from *Ribes nigrum* and were successful on the following hosts: *Ribes alpinum* ♀, *R. americanum*, *R. aureum chrysococcum*, *R. Cynosbati*, *R. Cynosbati inerme*, *R. divaricatum*, *R. fasciculatum chinense*, *R. Grossularia* (*uva-crispa*), *R. hirtellum*, *R. holosericeum*, *R. intermedium*, *R. longiflorum*, *R. luridum*, *R. nigrum*, *R. nigrum aconitifolium*, *R. oxyacanthoides*, *R. robustum*, *R. tenue*, *R. vulgare*, *Ribes* sp. (Smith's small gooseberry). That twenty species took out of thirty-one tried, as compared with fifteen out of twenty-five where the II spores were from *Ribes vulgare* (*q. v.*) were used, was due probably to the fact that more inoculations were made on each host and more spores used. In general the species inoculated from these two hosts corresponded quite closely in results obtained. Altogether eighty inoculations were made from *R. nigrum*, of which thirty-three or 41% were successful, which is lower than from *Ribes vulgare*, but the number of sori produced was greater than with the latter host.

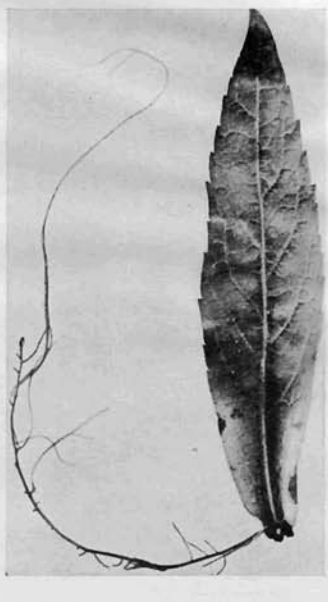
II stage from *Ribes nigrum*: on *Parnassia caroliniana*, 565, 0.3, '18, failed: on *Ribes alpestre*, 375, S. 13, '18, failed; 526, S. 28, '18, failed; 1038, Au. 6, '19, failed; 1061, Au. 13, '19, failed: on *R. alpinum* ♀, 428, S. 17, '18, fair, II, III: on *R. alpinum* ♂, 376, S. 13, '18, failed; 523, S. 28, '18, failed; 1030, Au. 6, '19, failed; 1059, Au. 13, '19, failed: on *R. americanum*, 374, S. 13, '18, fair, II, III; 1047, Au. 7, '19, failed; 1057, Au. 13, '19, failed: on *R. aureum*, 1040, Au. 7, '19, failed; 1065, Au. 13, '19, failed: on *R. aureum chrysococcum*, 392, S. 13, '18, good, II, III; 398, S. 14, '18, failed; 527, S. 28, '18, failed; 1043, Au. 7, '19, failed; 1068, Au. 13, '19, failed: on *R. caucasicum*, 381, S. 13, '18, failed; 524, S. 28, '18, failed; 1032, Au. 6, '19, failed: on *R. curvatum*, 380, S. 13, '18, failed; 529, S. 28, '18, failed; 1051, Au. 7,'19, failed; 1056, Au. 13, '19, failed: on *R. Cynosbati*, 377, S. 13, '18, good, II; 396, S. 14, '18, good, II; 1041, Au. 7, '19, poor, II: on *R. Cynosbati inerme*, 397, S. 14, '18, poor, II; 1036, Au. 6, '19, fair, II: on *R. diacantha*, 429, S. 17, '18, failed: on *R. divaricatum*, 379, S. 13, '18, good, II; 1037, Au. 6, '19, failed: on *R. fasciculatum chinense*, 399, S. 14, '18, good, II: on *R. Grossularia*, 1033, Au. 6, '19, failed: on *R. Grossularia* (*uva-crispa*), 382, S. 13, '18, fair, II: on *R. giraldii*, 378, S. 13, '18, failed; 528, S. 28, '18, failed; 1053, Au. 7, '19, failed; 1067, Au. 13, '19, failed: on *R. hirtellum*, 383, S. 13, '18, good, II, III; 1049, Au. 7, '19, failed: on *R. holosericeum*, 384, S. 13, '18, failed; 525, S. 28, '18, failed; 1048, Au. 7, '19, fair, II, III; 1063, Au. 13, '19, failed: on *R. intermedium*, 385, S. 13, '18, good, II, III; 1044, Au. 7, '19, fair, II: on *R. longiflorum*, 400, S. 14, '18, fair, II, III: on *R. luridum*, 386, S. 13, '18, good, II, III; 1046, Au. 7, '19, failed: on *R. nigrum*, 387,

PLATE XXVI

a. II stage of *Cronartium Comptoniae* on *Myrica asplenifolia*, pp. 479, 484.

b. Callus on petiole of *Ribes nigrum*, p. 480.

c. II stage of *Cronartium ribicola* on *Ribes nigrum*, p. 485.



d. Roots from callus on *Solidago rugosa*, p. 480.

ARTIFICIAL INOCULATIONS IN PETRIE DISHES.

S. 13, '18, good, II, III; 997, Jl. 12, '19, fair, II; 1069, Au. 5, '19, excellent, II, III: on *R. nigrum aconitifolium*, 388, S. 13, '18, good, II, III; 1035, Au. 6, '19, fair, II, III; 1058, Au. 13, '19, fair, II: on *R. oxyacanthoides*, 395, S. 13, '18, good, II, III: on *R. robustum*, 391, S. 13, '18, good, II, III; 1031, Au. 6, '19, poor, II; 1064, Au. 13, '19, fair, II, III: on *R. stenocarpum*, 390, S. 13, '18, failed; 522, S. 28, '18, failed; 1045, Au. 7, '19, failed; 1062, Au. 13, '19, failed: on *R. tenue*, 389, S. 13, '18, good, II, III; 1042, Au. 7, '19, failed; 1060, Au. 13, '19, failed: on *R. vulgare*, 394, S. 13, '18, fair, II, III: on *R. vulgare* (white currant), 1050, Au. 7, '19, failed: on *Ribes* sp. (large gooseberry), 1052, Au. 7, '19, failed: on *Ribes* sp. (Smith's small gooseberry), 393, S. 13, '18, fair, II, III; 1034, Au. 6, '19, failed; 1066, Au. 13, '19, failed.

II from *Ribes nigrum* (Petri dish): on *R. nigrum*, 366, Je. 26, '18, good, II; 508, S. 25, '18, poor, III; 645, D. 9, '18, failed; 1027, Jl. 28 '19, fair, II.

Inoculations with II stage from *Ribes vulgare*. In this series the II spores were all from *Ribes vulgare* and successful inoculations were made on the following hosts: *Ribes americanum, R. Cynosbati, R. Cynosbati inerme, R. fasciculatum chinense, R. Grossularia (uva-crispa), R. hirtellum, R. intermedium, R. longiflorum, R. luridum, R. nigrum, R. nigrum aconitifolium, R. orientale, R. oxyacanthoides, R. robustum*, and *Ribes* sp. (Smith's small gooseberry). The best results were obtained with *R. Cynosbati, R. longiflorum, R. nigrum*, and *R. oxyacanthoides*. Of the twenty-seven inoculations made fifteen, or 56%, were successful. All the inoculations, except the last two, were made on Sept. 17, 1918.

II stage from *Ribes vulgare*: on *R. alpestre*, 402, failed: on *R. alpinum* ♀, 427, failed: on *R. alpinum* ♂, 403, failed: on *R. americanum*, 401, poor, II: on *R. aureum chrysococcum*, 420, failed: on *R. caucasicum*, 405, failed: on *R. curvatum*, 409, failed: on *R. Cynosbati*, 404, good, II: on *R. Cynosbati inerme*, 406, poor, II: on *R. fasciculatum chinense*, 421, poor, II: on *R. Grossularia (uva-crispa)*, 410, poor, II, III: on *R. giraldii*, 407, failed: on *R. hirtellum*, 412, poor, II: on *R. holosericeum*, 411, failed: on *R. intermedium*, 413, poor, II, III: on *R. longiflorum*, 425, good, II, III: on *R. luridum*, 414, poor, II, III: on *R. nigrum*, 415, good, II, III: on *R. nigrum aconitifolium*, 416, poor, II, III: on *R. orientale*, 422, poor, II: on *R. oxyacanthoides*, 426, good, II: on *R. robustum*, 417, poor, II, III: on *R. stenocarpum*, 418, failed: on *R. tenue*, 419, failed: on *R. vulgare*, 424, failed; 998 (Fay's Prolific), Jl. 12, '19, failed: on *Ribes sp.* (Smith's small gooseberry), 423, S. 17, '18, poor, III.

Inoculations with II stage from *Ribes* sps. The host species from which the II spores were obtained are uncertain but the results were quite successful in each case.

II from *Ribes* sp.: on *R. nigrum*, 299, My. 27, '18, good, II; 329, Je. 3, '18, good, II; 331, Je. 5, '18, excellent, II, III: on *R. vulgare*, 300, My. 27, '18, good, II.

Inoculations from III stage. There was no indication from these experiments that the III stage from *Ribes* could re-inoculate *Ribes*. When tried on pine leaves, however, the results were successful in one case where the juvenile-form leaves were still attached to a young shoot. Results as a rule are not to be expected even here as no sign of infection is usually visible for a month or two after inoculation. In the successful case reported there was a slight golden-yellow spotting thirty-eight days after inoculation and sections showed the characteristic sclerotial masses present.

III stage from *Ribes nigrum:* on *Pinus Strobus*, 584 (stem uncut), O. 7, '18, failed; 585 (stem cut), O. 7, 18, failed; 589 (stems uncut and buds), O. 8, '18, failed; 583 (leaves), O. 7, '18, failed; 588, O. 8, '18, good, (yellow spots and sclerotia): on *Ribes intermedium*, 1112, O. 25 '19, failed: on *R. nigrum*, 631, O. 19, '18, failed; 1113, O. 25, '19, failed.

Gymnoconia interstitialis (Schl.) Lagerh.

Infections from the I stage resulted from *Rubus allegheniensis* on *R. allegheniensis* and *R. villosus*; from *R. hispidus* on *R. hispidus* and *R. villosus;* from *R. occidentalis* on *R. hispidus;* from *R. villosus* on *R. hispidus* and *R. villosus*. The III stage appeared in all cases. Only ten out of forty-six infections, or 22% were successful. This low rate is due in part to the leaves not keeping in good condition long enough to secure results, as it takes some time for the sori to mature.

I stage from *Rubus allegheniensis* (*R. villosus*): on *R. allegheniensis* (wild), 1357, Je. 30, '20, fair, III: on *R. villosus*, 336, 337, Je. 6, '18, failed; 1358, Je. 30, '20, good, III.

I stage from *Rubus hispidus*: on *R. hispidus*, 4302, Je. 2, '23, fair, III; 4340, Je. 15, '23, failed: on *R. villosus*, 338, 339, Je. 6, '18, failed; 959, Je. 11, '19, excellent, III; 3087, Je. 5, '22, failed; 4295, Je. 1, 4203, Je. 2, '23, failed; 4341, Je. 15, '23, good, III: on *Rubus*, sps. (wild and cult. raspberry), 3084, 3085, Je. 5, '22, failed; 4296, Je. 1, '23, failed: on *Rubus* sp. (cult. blackberry), 3086, Je. 5, '22, failed; 4294, Je. 1, '23, failed. See Plate XXVb.

I stage from *Rubus occidentalis:* on *R. allegheniensis*, 1350 (wild), 1354 (Erie), 1356, (Snyder), Je. 22, '20, failed; 3090 (cult.), Je. 5, '22, failed; 4310 (cult.), Je. 8, '23, failed; 4353 (cult.), Je. 20, '23, failed; 4356, Je. 20, '23, failed: on *R. hispidus*, 4311, Je. 8, '23, poor, III; 4354, Je. 20, '23, failed; 4357, Je. 20, '23, failed: on *R. occidentalis*, 1346, 1352, Je. 22, '20, failed: on *R. villosus*, 1348, Je. 22, '20, failed; 3091, Je. 5, '22, failed; 4309, Je. 8, '23, failed; 4352, Je. 20, '23, failed; 4355, Je. 20, '23, failed; 4581, Jl. 2, '24, failed: on *Rubus* sps. (cult. and wild raspberry), 3088–89, Je. 5, '22, failed.

I stage from *Rubus villosus* (*R. canadensis*): on *R. allegheniensis*, 4326, Je. 12, '23, failed; on *R. hispidus*, 4338, Je. 15, '23, excellent, III: on *R. villosus*, 4325, Je. 12, '23, poor, III; 4339, Je. 15, '23, failed; 4580, Jl. 2, '24, good, III; 4585, Jl. 10, '24, excellent, III.

I stage from *Rubus* sps. (wild raspberry): on *R. villosus*, 960, Je. 11, '19, failed: on *Rubus* sps. 970, Je. 13, '19, failed.

Gymnosporangium.

Of the five species tried from this genus we were successful in securing infections with only two, chiefly because the wrong host or the O stage was used with the other three. Altogether thirty-nine tests were made of which fourteen or 36% were successful. With *G. Juniperi-virginianae*, where more likely hosts were used, 46% of the inoculations were successful. With *Gymnosporangium* successful results in Petri dishes are to be expected only with the III stage and with this only the O stage appears since the length of time to develop the I stage is too great to keep the leaves alive.

Gymnosporangium clavariaeforme (Jacq.) DC.

This failure is probably due to the use of the wrong host, as *Pyrus* is not given by Kern (N. A. F.) as one for this species which usually occurs on *Amelanchier* sps., and *Cydonia vulgaris*, both hosts in Connecticut.

III stage from *Juniperus communis*: on *Pyrus ioensis* (Bechtel's Fl. Crab), 923, My. 27, '19, failed.

Gymnosporangium clavipes Ck. & Pk.

The usual hosts for this species are *Amelanchier*, *Crataegus* and *Cydonia*, although Kern (N. A. F.) gives *Pyrus Malus* as a host from Massachusetts. *Pyrus*, however, does not seem to be a very susceptible host from our results.

O stage from *Amelanchier* sp.: on *Pyrus ioensis*, 936, Je. 6, '19, failed. III stage from *Juniperus virginiana*: on *Pyrus ioensis* (Bechtel's Fl. Crab) 922, My. 27, '19, failed: on *P. Malus* (Wealthy) 811, My. 20, '19, failed.

Gymnosporangium cornutum (Pers.) Arth.

As in all species tried no results were obtained from inoculations with the O stage. This rust, however, has not been listed on the hosts tried here so the results do not mean so much as if *Sorbus* had been used.

O stage from *Sorbus americana*: on *Crataegus crus-galli*, 967, Je. 12, '19, failed: on *Pyrus ioensis*, 968, Je. 12, '19, failed: on *P. Malus* (Wealthy), 969, Je. 12, '19, failed.

Gymnosporangium Juniperi-virginianae Schw.

Here inoculations with the O stage were made on hosts known to be very susceptible but without results which seems to indicate that the O stage is not a means of spreading the rust. Inoculations with the III stage were successful on *Pyrus ioensis* and *P. Malus* only, the other species, *Pyrus communis* and *Cydonia vulgaris*, not being reported as hosts for this species by Kern. All three inoculations took on the Bechtel's Flowering Crab which is a very susceptible species. On *Pyrus Malus*, however, the results varied with the different varieties used, failing on Baldwin, Gravenstein, McIntosh and Northern Spy, taking poorly on Fall Pippin, Greening, King and Sutton's Beauty, and taking well on Duchess of Oldenburg, Hurlburt, Russet and Wealthy. These results agree well with the observations we have made on these varieties in nature. The Petri dish method seems to be a very easy way to test the susceptibility of different varieties of apples to these rusts. Of the inoculations with the III stage 52% were successful.

O stage from *Pyrus Malus*: on *Pyrus ioensis*, 953, Je. 9, '19, failed: on *Pyrus Malus* (Wealthy), 954, Je. 9, '19, failed; 4030–32 (young and old leaves), Je. 20, '22, failed.

I stage from *Pyrus Malus*: on *Juniperus virginiana*, 1029, Au. 5, '19, failed.

III stage from *Juniperus virginiana*: on *Cydonia vulgaris*, 801, My. 19, '19, failed; 940, Je. 7, '19, failed: on *Pyrus communis*, 800, My. 19, '19, failed; 938 (Seckel), Je. 7, '19, failed; 939, Je. 7, '19, failed: on *P. ioensis* (Bechtel's Fl. Crab), 799, My. 19, '19, excellent, O; 924, My. 27, '19, poor, O; 937, Je. 7, '19, good, O; 4306, Je. 7, '23, excellent, O: on *P. Malus*, 798, My. 19, '19, failed; 810 (Baldwin), My. 20, '19, failed; 942 (Baldwin), Je. 7, '19, failed; 943 (Duchess of Oldenberg), Je. 7, '19, good, O; 941 (Fall Pippin), Je. 7, '19, poor, O; 946 (Gravenstein), Je. 7, '19, failed; 952 (Greening), Je. 7, '19, poor, O; 950 (Hulbert), Je. 7, '19, good, O; 946 (King), Je. 7, '19, poor, O; 947 (McIntosh), Je. 7, '19, failed; 944 (Northern Spy), Je. 7, '19, failed; 951 (Russet), Je. 7, '19, good, O; 948 (Sutton's Beauty), Je. 7, '19, poor, O; 809 (Wealthy), My. 20, '19, good, O; 949 (Wealthy), Je. 7, '19, poor, O. See Plate XXVc.

Gymnosporangium nidus-avis Thaxt.

Successful inoculations were made with this species only on Quince (*Cydonia vulgaris*) and the Wealthy apple, failing on the other varieties of *Pyrus Malus*, the Pear and Bechtel's Crab. Wealthy is one of the most susceptible varieties of apples to *Gymnosporangium Juniperi-virginianae* but Kern (N. A. F. **7**[3]: 196.) does not list *Pyrus Malus* as a host for *G. nidus-avis* and it may be that in nature it does not attack the apple.

III stage from *Juniperus virginiana:* on *Cydonia vulgaris*, 805, My. 19, '19, fair, O: on *Pyrus communis*, 804, My. 19, '19, failed: on *P. ioensis*, 803, My. 19, '19, failed: on *P. Malus*, 802, My. 19, '19, failed; 813 (Baldwin), My. 20, '19, failed; 812 (Wealthy), My. 20, '19, fair, O.

Kuehneola albida (Kuehn) Magn.

Only two inoculations out of nine were successful with this species, taking from *Rubus allegheniensis* and *R. hispidus* on the same species. This seems too low considering the hosts and character of the spore material used, but perhaps the lateness of the season with some of the inoculations explains their failure.

II stage from *Rubus allegheniensis:* on *R. allegheniensis*, 1070, S. 9, '19, poor, II: on *R. villosus*, 1071, S. 9, '19, failed: on *Rubus* sp. (raspberry), 1072, S. 9, '19, failed.

II stage from *Rubus hispidus:* on *R. hispidus*, 4298, Je. 1, '23, fair, II: *R. villosus*, 4297, Je. 1, '23, failed.

II stage from *Rubus villosus*: on *R. villosus*, 4621, S. 16, '24, failed.

II stage from *Rubus* sp. (wild blackberry), on *R. allegheniensis*, 1546, N. 10, '20, failed: on *R. villosus*, 1545, N. 10, '20, failed: on *Rubus* sp. (cult. raspberry), 1547, N. 10, '20, failed.

Melampsora sps.

We have carried on a considerable number of inoculations with *Melampsora* species from *Populus* and *Salix* on various species of *Betula, Populus* and *Salix*. Uniform failure to inoculate *Betula*, on both trees and in Petri dishes, has eliminated the rust on that host from consideration, on infectional as well as on morphological grounds, as stated subsequently under *Melampsoridium*. The only reason for making these inoculations was the frequent association of the *Betula* rust with those on *Populus* and *Salix*.

Examining our Connecticut herbarium specimens on *Populus* and *Salix*, we find that there are slight morphological characters that apparently separate them into four species, two on *Salix* and two on *Populus*. Yet we are not sure whether these might not be more satisfactorily combined in fewer species. Our inoculations have also given conflicting results, II spores from both *Populus grandidentata* and *P. tremuloides* having apparently infected leaves of *Salix;* also II spores from *Populus tremuloides* took on *P. grandidentata* but not from the latter on the former, while II spores from *Salix* sp. failed on both the poplars. The rusts on these three hosts have been found associated in the same locality with *Caeoma Abietis-canadensis* and their II stages are very similar. All these observations have caused us to question whether we were dealing with three or one species. See notes under each.

Melampsora Abietis-canadensis (Farl.) Ludw.

The inoculations with the I stage (*Caeoma Abietis-canadensis*) from *Tsuga canadensis* took in all the tests (except possibly one) on *Populus grandidentata* and failed on *Betula* and *Salix* sps. and on all the other species of *Populus* except one doubtful sorus on *P. tremuloides*, the other two trials on this host failing though taking at the same time on *P. grandidentata*. The inoculations with the II stage from *Populus grandidentata* were uniformly failures, even on *P. grandidentata*, except the very suspicious infection on *Salix* sp. which leaves possibly were already infected, as the first sori appeared within five days after inoculation.

I stage from *Tsuga canadensis:* on *Betula* sp., 4010, Je. 17, '22, failed: on *Populus alba*, 4009, Je. 16, '22, failed; 4014, Je. 17, '22, failed: on *P. deltoides*, 3096, Je. 15, '22, failed: on *P. grandidentata*, 3094, Je. 15, '22, fair, II; 4011, Je. 17, '22, poor, II; 4021, Je. 19, '22, failed?; 4586, Jl. 10, '24, poor, II: on *P. nigra italica*, 3093, Je. 15, 4013, Je. 17, '22, failed: on *P. tremuloides*, 3095, Je. 15, '22, poor, II (one sorus); 4012, Je. 17, '22, failed; 4587, Jl. 10, '24, failed: on *Salix* sps., 4401–2, Je. 15, '22, failed; 4015–18, Je. 17, '22, failed; 4022–29, Je. 19, '22, failed.

II stage from *Populus grandidentata*: on *Betula lenta*, 557, O. 2, '18, failed: on *B. populifolia*, 554, O. 2, '18, failed: on *Populus deltoides*, 1510, O. 28, '20, failed: on *P. grandidentata*, 560, O. 2, '18, failed; 1498, O. 27, '20, failed; 1500, O. 28, '20, failed: on *P. tremuloides*, 563, O. 2, '18, failed; 1497, O. 27, '20, failed: on *Salix* sp. (New Haven), 1501, O. 28, '20, fair, II.

Melampsora americana Arth.

The II stage from *Salix* sps. failed on the three species of *Betula* and the six of *Populus* that were inoculated. It also failed on certain species of *Salix* but took on others, six of the twelve inoculations being successful.

II stage from *Salix* sp: on *Betula alba papyrifera*, 448, S. 20, '18, failed: on *B. lenta*, 449, S. 20, '18, failed; 1451, O. 14, '20, failed; 1489, O. 27, '20, failed; 1512, O. 28, '20, failed: on *B. populifolia*, 450, S. 20, '18, failed; 1450, O. 14, '20, failed; 1490, O. 27, '20, failed; 1513, O. 28, '20, failed: on *Populus alba*, 451, S. 20, '18, failed; 1509, O. 28, '20, failed; 1519, O. 28, '20, failed: on *P. balsamifera*, 452, S. 20, '18, failed: on *P. deltoides*, 453, S. 20, '18, failed; 1504, O. 28, '20, failed; 1520, O. 28, '20, failed: on *P. grandidentata*, 454, S. 20, '18, failed; 1449, O. 14, '20, failed; 1492, O. 27, '20, failed; 1507, 1517, O. 28, '20, failed: on *P. nigra italica*, 455, S. 20, '18, failed; 1508, 1518, O. 28, '20, failed: on *P. tremuloides*, 456, S. 20, '18, failed; 1448, O. 14, '20, failed; 1491, O. 27, '20, failed; 1506, 1516, O. 28, '20, failed: on *Salix amygdalina* (3), 484, S. 21, '18, poor, II; 495, S. 21, '18, failed: on *S. amygdalina americana* (2), 494, S. 21, '18, failed: on *S. pentandra* (5, Lemley), 497, S. 21, '18, poor, II; 1502, 1514, O. 28, '20, failed; on *S. purpurea* (1 and 4), 493, 496, S. 21, '18, failed; on *Salix* sp. (New Haven), 1447, O. 14, '20, poor, II; 1503, O. 28, '20, good, II; 1505, O. 28, '20, poor, II; 1515, O. 28, '20, poor, II.

Melampsora Medusae Thuem.

The inoculations with the II stage from *Populus tremuloides* on the same host took in good shape in three out of the four trials and failed on all the other species of *Populus*, *Betula* and *Salix*, except apparently in one case on *Populus grandidentata* and one on *Salix* sp. made at the same time and with same material that took on *P. tremuloides*. This means either that these two latter hosts were already infected when used or else that all three hosts are inhabited by the same species and not by three different ones as considered here.

II stage from *Populus tremuloides:* on *Betula alba*, 430, S. 20, '18, failed: on *Betula lenta*, 431, S. 20, '18, failed; 558, O. 2, '18, failed; 1461, O. 14, '20, failed: on *B. populifolia*, 432, S. 20, '18, failed; 555, O. 2, '18, failed; 1460, O. 14, '20, failed: on *Populus alba*, 433, S. 20, '18, failed: on *P. balsamifera*, 434, S. 20, '18, failed: on *P. deltoides*, 435, S. 20, '18, failed: on *P. grandidentata*, 436, S. 20, '18, failed; 561, O. 2, '18, failed; 1459, O. 14, '20, good, III: on *P. nigra italica*, 437, S. 20, '18, failed: on *P. tremuloides*, 438, S. 20, '18, good, II; 465, S. 20, '18, fair, II-III; 564, O. 2, '18, failed; 1458, O. 14, '20, good, II: on *Salix amygdalina* (3), 505, S. 21, '18, failed: on *S. amygdalina americana* (2), 504, S. 21, '18, failed: on *S. pentandra* (5), 507, S. 21, '18, failed: on *S. purpurea* (1), 503, S. 21, '18, failed: *S. purpurea* (4), 506, S. 21, '18, failed: on *Salix* sp. (New Haven), 1457, O. 14, '20, poor, II.

Melampsoridium betulinum (Pers.) Kleb.

All six inoculations with the I stage failed, but only one was made on *Betula* species. Only 18% of the thirty-three inoculations with the II stage was successful also for the reason that many of them were made on *Populus* and *Salix*. In this state rusts on *Populus*, *Salix* and *Betula* often occur together and it was thought that possibly there might be some connection between them not yet discovered. As far as *Betula* is concerned both from these experiments and microscopical examination of the II stage found on it, there is but one species of rust and it does not occur on either *Populus* or *Salix*. If we consider only the inoculation from *Betula* sps. to *Betula* sps., the results are better, since 38% of these was successful. The favorable inoculations with the II stage were as follows: from *Betula populifolia* on *B. lenta* and *B. populifolia*. In the case of spores from *B. lenta* on these two hosts the results were negative probably because the number of inoculating spores was small.

I stage from *Larix americana:* on *Betula* sp., 4316, Je. 8, '23, failed: on *Populus deltoides*, 4314, Je. 8, '23, failed: on *P. grandidentata*, 4312, Je. 8, '23, failed: on *P. nigra italica*, 4313, Je. 8, '23, failed: on *Salix* sp., 4305, Je. 7, 4315, Je. 8, '23, failed.

II stage from *Betula lenta:* on *B. lenta*, 1485, O. 27, '20, failed: on *B. populifolia*, 1486, O. 27, '20, failed: on *Populus grandidentata*, 1488, O, 27, '20, failed: on *P. tremuloides*, 1487, O. 27, '20, failed.

II stage from *Betula populifolia:* on *B. alba papyrifera*, 439, S. 20, '18, failed: on *B. lenta*, 440, S. 20, '18, failed; 556, O. 2, '18, failed; 1456, O. 14, '20, poor, II; 1493, O. 27, '20, fair, II: on *B. populifolia*, 441, S. 20, '18, fair, II; 553, O. 2, '18, failed; 1455, O. 14, '20, failed; 1494, O. 27, '20, failed; 1499, O. 28, '20, poor, II; 1511, O. 28, '20, poor, II: on *Populus alba*, 442, S. 20, '18, failed: on *P. balsamifera*, 443, S. 20, '18, failed: on P. *deltoides*, 444, S. 20, '18, failed: on *P. grandidentata*, 445, S. 20, '18, failed; 559, O. 2, '18, failed; 1454, O. 14, '20, failed; 1496, O. 27, '20, failed: on *P. nigra italica*, 446, S. 20, '18, failed: on *P. tremuloides*, 447, S. 20, '18, failed; 562, O. 2, '18, failed; 1453, O. 14, '20, failed; 1495, O. 27, '20, failed: on *Salix amygdalina* (3), 500, S. 21, '18, failed: on *S. amygdalina americana* (2), 499, S. 21, '18, failed: on S. *purpurea* (1), 498, S. 21, '18, failed: on *S. purpurea* (4), 501, S. 21, '18, failed: on *S. pentandra* (5), 502, S. 21, '18, failed: on *Salix* sp., 1452, O. 14, '20, failed.

Melampsoropsis Cassandrae (Pk. & Clint.) Arth.

The results in this case are interesting since they confirm results obtained with plants in crocks, namely that *Picea mariana* and *P. rubra* are susceptible hosts for producing the O and I stages of this rust, while *P. excelsa* is not. The inoculations in the Petri dishes were made on leaves still attached to small branches and the O stage with pycniospores only appeared, the I stage appearing on the plants in the crocks.

III stage from *Cassandra calyculata:* on *Picea excelsa*, 347, Je. 8, '18, failed; 925, My. 27, '19, failed: on *P. mariana*, 956, Je. 11, '19, fair, O: on *P. rubra*, 972, Je. 14, '19, fair, O.

Melampsoropsis Pyrolae (D.C.) Arth.

This rust apparently winters over here through the II stage, as the I stage has not been found. It is not evident why the two inoculations with the II stage failed since the leaves remained alive and healthy in the Petri dishes for a long time, and the spores seemed in good condition when used.

II stage from *Pyrola americana:* on *P. americana,* 4301, Je. 2, '23, failed: on *P. elliptica,* 4300, Je. 2, '23, failed.

Phragmidium Potentillae (Pers.) Karst.

Inoculations were successful in two out of the three tests of the II stage on *Potentilla canadensis* on the same host. The other attempts were made on plants known not to be the proper hosts.

II stage from *Potentilla canadensis*: on *Betula populifolia,* 569, O. 3, '18, failed: on *Populus grandidentata,* 568, O. 3, '18, failed: on *P. tremuloides,* 567, O. 3, '18, failed: on *Potentilla canadensis,* 566, O. 3, '18, failed; 996, Jl. 12, '19, poor, II; 1014, Jl. 19, '19, fair, II; 1014, II, a-b, Au. 5, '19, (a) excellent, II, (b) failed. See Plate XXVa.

Phragmidium subcorticium (Schr.) Wint.

With this species five out of the nine inoculations on *Rosa* species were successful. The failures seem to indicate that they were on varieties that were at least somewhat resistant to the rust.

II stage from *Rosa* sp. (cult.): on *Rosa rugosa,* 987, Jl. 12, '19, failed: on *Rosa* sp. (The Farquhar), 993, Jl. 12, '19, failed: on *Rosa* sp. (Ayrshire), 989, Jl. 12, '19, failed: on *Rosa* sp., 992, Jl. 12, '19, poor, II: on *Rosa* sp. (Frau Karl Druschki's hybrid perpetual), 994, Jl. 12, '19, poor, II: on *Rosa* sp. (Madame Plantier), 991, Jl. 19, '19, poor, II: on *Rosa* sp. (white), 990, Jl. 12. '19, poor, II: on *Rosa* sp. (Wichuraina), 988, Jl. 12, '19, failed.

II stage from *Rosa* sp. (Madame Plantier, Petri dish culture 991): on *Rosa* sp. (Madame Plantier), 1025, Jl. 25, '19, poor, II.

Puccinia sps.

We can discuss the results of inoculation with species of *Puccinia* altogether as the number of inoculations with most of them were too few to draw any special conclusions. In fact the work with *Puccinia,* as with *Uromyces,* was chiefly to determine how successful the Petri dish method would prove for those species of rusts that have their hosts on the more delicate leaves of herbaceous plants, many of which are also of such size that they have to be cut before they can be placed in the dish. Of the forty-six inoculations 35% was successful which is fair considering the difficulty of keeping the leaves in good condition. However, even with the successful ones, the amount of infection was not usually very abundant and often the sori appeared only shortly before the leaves died.

Altogether nineteen species of *Puccinia* were tried and infection resulted in nine as follows. *Puccinia Agropyri*: II stage from *Agropyron repens* on *A. repens*; II stage from *Triticum vulgare* on *Agropyron repens. Puccinia coronata*: II stage from *Avena sativa* on *A. sativa*. *Puccinia graminis*: II stage from *Agrostis alba* on *A. alba*; II stage from *Phleum pratense* on *P. pratense*. *Puccinia obscura:* II stage from *Luzula campestris* on *L. campestris*. *Puccinia Poarum:* II stage from *Poa pratensis* on *P. pratensis*. *Puccinia Pruni-spinosae:* I stage from *Anemone quinquefolia* on *Prunus serotina*. *Puccinia suaveolens:* II stage from *Cirsium arvense* on *C. arvense*. *Puccinia Violae:* I stage from *Viola blanda* on *V. blanda*. *Puccinia Thalictri:* III stage from *Thalictrum polygamum* on *P. polygamun*. (This last infection is considered doubtful).

Puccinia Agropyri Ell. & Ev.

I stage from *Thalictrum polygamum:* on *Carex* sp., 4332, Je. 13, '23, failed.

II stage from *Agropyron repens:* on *A. repens*, 1013, Jl. 19, '19, poor, II; 1028, Jl. 28, '19, failed; 4346, Je. 16, '23, failed: on *Panicum* sp., 999, Je. 12, '19, failed.

II stage from *Triticum vulgare:* on *Agropyron repens*, 1023, Jl. 19, '19, poor, II.

Puccinia Andropogi Schw.

I stage from *Chelone glabra:* on *Andropogon scoparius*, 4330, Je. 13, '23, fair, II; 4342, Je. 15, '23, failed.

III stage from *Andropogon scoparius:* on *Chelone glabra*, 4331, Je. 13, '23, failed.

Puccinia Anemones Pers.

III stage from *Anemone quinquefolia* (poor material): on *A. quinquefolia*, 4321, Je. 12, '23, failed: on *Thalictrum* sp., 4320, Je. 12,'23, failed.

Puccinia Asparagi DC.

II stage from *Asparagus officinalis:* on *A. officinalis*, 1055, Au. 12, '19, failed.

Puccinia coronata Cda.

II stage from *Avena sativa:* on *A. sativa*, 581, O. 7, '18, fair, II; 632, O. 22, '18, good, II, III; 641, O. 31, '18, poor, II; (II stage from Petri dish culture 632), 642, O. 31, '18, poor, II: on *Secale cereale*, 633, O. 22, '18, failed.

Puccinia Ellisiana Thuem.

I stage from *Viola* sp.: on *Andropogon* sp., 4343, Je. 15, '23, failed: on *Viola* sp., 4334, Je. 15, '23, failed.

Puccinia Eriophori Thuem.

I stage from *Senecio aureus:* on *Eriophorum viridi-carinatum*, 4322, Je. 12, '23, failed.

III stage from *Eriophorum viridi-carinatum:* on *Senecio aureus*, 4324, Je. 12, '23, failed.

Puccinia Fraxinata (Lk.) Arth.

I stage from *Fraxinus americana:* on *Agropyron repens*, 1010, Jl. 19, '19, failed: on *Fraxinus americana*, 1008, Jl. 19, '19, failed: on *Spartina patens juncea*, 1003, Jl. 18, '19, failed; 1005, Jl. 19, '19, failed: on *Spartina* sp. (large), 1002, Jl. 18, '19, failed; 1004, Jl. 19, '19, failed.

Puccinia graminis Pers.

I stage from *Berberis vulgaris:* on *Agrostis alba*, 4329, Je. 13, '23, failed.
II stage from *Agrostis alba:* on *A. alba*, 1011, Jl. 19, '19, poor, II.
II stage from *Phleum pratense:* on *P. pratense*, 1012, Jl. 19, '19, fair, II.

Puccinia Malvacearum Mont.

III stage from *Althaea rosea:* on *A. rosea*, 995, Jl. 12, '19, failed.

Puccinia obscura Schroet.

II stage from *Luzula campestris:* on *L. campestris*, 359, Je. 21, '18, failed; 934, Je. 6, '19, good, II.

Puccinia Poarum Niels.

II stage from *Poa pratensis:* on *P. pratensis*, 1000, Jl. 12, '19, poor, II.

Puccinia Porri (Sow.) Wint.

II stage from *Allium cepa* (Egyptian): on *A. cepa* (garden), 1054, Au. 12, '19, failed.

Puccinia Pruni-spinosae Pers.

I stage from *Anemone quinquefolia:* on *Prunus persica*, 4249, My. 19, '23, failed: on *Prunus serotina*, 900, My. 27, '19, poor, II; 4250, My. 19, '23, excellent, II: on *Prunus* sp. (cult. plum), 4248, My. 18, '23, failed.

Puccinia rubigo-vera (DC.) Wint.

II stage from *Secale cereale:* on *S. cereale*, 344, Je. 8, '18, failed.

Puccinia suaveolens (Pers.) Rostr.

II stage from *Cirsium arvense:* on *C. arvense*, 1018, Jl. 19, '19, fair, II; 1026, Jl. 28, '19, poor, II.

Puccinia Taraxaci Plowr.

II stage from *Taraxacum officinale:* on *T. officinale*, 1001, Jl. 14, '19, failed (leaves decayed); 4345, Je. 16, '23, failed.

Puccinia Thalictri Chev.

III stage from *Thalictrum polygamum:* on *T. polygamum*, 4318, Je. 12, '23, good, III (telia appeared in six days so host possibly already infected)?; 4347, Je. 16, '23, failed.

Puccinia Violae (Schum.) DC.

I stage from *Viola blanda:* on *V. blanda*, 935, Je. 6, '19, good, II.

Pucciniastrum Myrtilli (Schum.) Arth.

The reason the I stage took on *Gaylussacia baccata* and failed on *Vaccinium vacillans* is not entirely evident since the latter, questionably, has been collected as host for the II and III stages in this state, and they were inoculated under apparently identical conditions. However, the *Gaylussacia* is a common host and the same year the inoculations were made we found it and *Vaccinium pennsylvanicum* infected together in a locality where *V. vacillans* was entirely free though close to the other infected hosts.

I stage from *Tsuga canadensis:* on *Gaylussacia baccata*, 4020, Je. 19, '22, excellent, II: 4041, Jl. 19, '22, good, II: on *Vaccinium vacillans*, 4019, Je. 19, '22, failed; 4042, Jl. 19, '22, failed.

Uromyces sps.

Only eight inoculations with five species of *Uromyces* were tried and of these only one was successful as follows. *Uromyces Trifolii:* II stage from *Trifolium pratense* on *T. pratense*.

Uromyces Caladii (Schw.) Farl.

I stage from *Arisaema triphyllum:* on *A. triphyllum*, 4307, Je. 8, '23, failed.

Uromyces Caryophyllinus (Schr.) Wint.

II stage from *Dianthus Caryophyllinus:* on *D. Carophyllinus*, 646, 647, 648, 649, D. 27, '18, failed.

Uromyces houstoniatus (Schw.) Sheld.

I stage from *Houstonia caerulea:* on *Hypoxis erecta*, 4282, My. 28, '23, failed: on *Luzula campestris*, 360, Je. 21, '18, failed: on *Sisyrinchium* sp., 4299, Je. 1, '23, failed.

Uromyces Lilii (Lk.) Fckl.

I stage from *Lilium* sp.: on *Lilium* sp., 361, Je. 21, '18, failed.

Uromyces Trifolii (Hedw.) Liro.

II stage from *Trifolium pratense:* on *T. hybridum*, 1017, Jl. 19, '19, failed: on *T. pratense*, 1015, Jl. 19, '19, poor, II.

TABLE I. RESULTS OF INOCULATIONS OF *Ribes* SPS. WITH *Cronartium ribicola*.

Comparison of Petri dish with pot inoculations.*

O—failure, P—poor, F—fair, G—good, E—excellent.

Scientific name of host inoculated.	I stage from Pinus Strobus.		II stage from Ribes species.		Average of tests.
	On leaves in Petri dishes.	On plants in crocks.	On leaves in Petri dishes.	On plants in crocks.	
Ribes alpestre	O in 3 tests.	O in 5 tests.	O in 5 tests.	No test.	O in 13 tests.
" alpinum ♂	O in 5 tests.	O in 2 tests.	O in 5 tests.	O in 1 test.	O in 13 tests.
" " ♀	P+ in 3 tests.	F+ in 4 tests.	F− in 3 tests.	P in 1 test.	F− in 11 tests.
" americanum	F− in 9 tests.	F− in 6 tests.	P− in 7 tests.	P in 2 tests.	P+ in 24 tests.
" aureum	P− in 5 tests.	F in 1 test.	O in 2 tests.	No test.	P− in 8 tests.
" " chrysococcum	P in 5 tests.	No test.	P− in 6 tests.	No test.	P− in 11 tests.
" caucasicum	F− in 4 tests.	F− in 3 tests.	O in 4 tests.	No test.	P+ in 11 tests.
" curvatum	O in 3 tests.	No test.	O in 5 tests.	No test.	O in 8 tests.
" Cynosbati	F+ in 3 tests.	F− in 1 test.	F− in 9 tests.	F in 1 test.	F− in 14 tests.
" " inerme	F in 1 test.	G in 1 test.	P+ in 3 tests.	No test.	F− in 5 tests.
" diacantha	F in 1 test.	F+ in 3 tests.	O in 1 test.	No test.	F− in 5 tests.
" divaricatum	F− in 5 tests.	G in 3 tests.	F− in 2 tests.	F in 1 test.	F+ in 11 tests.
" fasciculatum Chinense	F− in 3 tests.	F in 1 test.	F− in 4 tests.	No test.	F− in 8 tests.
" gracile	No test.	No test.	No test.	O in 1 test.	O in 1 test.
" Grossularia	O in 2 tests.	P in 1 test.	O in 1 test.	No test.	P− in 4 tests.
" " (uva-crispa)	F in 2 tests.	G in 1 test.	P+ in 2 tests.	No test.	F in 5 tests.
" giraldii	O in 6 tests.	O in 3 tests.	O in 5 tests.	No test.	O in 14 tests.
" hirtellum	P+ in 5 tests.	F+ in 4 tests.	P in 4 tests.	E in 1 test.	F− in 14 tests.
" holosericeum	F− in 2 tests.	No test.	P− in 5 tests.	No test.	P− in 7 tests.
" intermedium	F− in 6 tests.	G in 3 tests.	P+ in 5 tests.	G in 1 test.	F− in 15 tests.
" longiflorum	P in 1 test.	No test.	G− in 2 tests.	No test.	F in 3 tests.
" luridum	F− in 6 tests.	G− in 3 tests.	P+ in 5 tests.	P in 1 test.	F− in 15 tests.

TABLE I. RESULTS OF INOCULATIONS OF *Ribes* SPS. WITH *Cronartium ribicola*.

Comparison of Petri dish with pot inoculations.—*Concluded*.

O—failure, P—poor, F—fair, G—good, E—excellent.

Scientific name of host inoculated.	I stage from Pinus Strobus.		II stage from Ribes species.		Average of tests.
	On leaves in Petri dishes.	On plants in crocks.	On leaves in Petri dishes.	On plants in crocks.	
Ribes multiflorum	O in 1 test.	No test.	No test.	No test.	O in 1 test.
" nigrum	F + in 27 tests.	G − in 19 tests.	F + in 35 tests.	F in 23 tests.	F + in 104 tests.
" " aconitifolium	P in 2 tests.	No test.	F in 4 tests.	No test.	F − in 6 tests.
" odoratum	G in 1 test.	O in 1 test.	No test.	No test.	F in 2 tests.
" orientale	O in 1 test.	No test.	P in 1 test.	O in 1 test.	P − in 3 tests.
" oxyacanthoides	G in 8 tests.	F + in 6 tests.	F − in 5 tests.	P + in 3 tests.	F + in 22 tests.
" petraeum	No test.	F in 1 test.	No test.	No test.	F in 1 tests.
" pinetorum	O in 1 test.	G in 2 tests.	No test.	G in 1 test.	F + in 4 tests.
" robustum	F − in 5 tests.	G − in 2 tests.	P + in 7 tests.	No test.	F − in 14 tests.
" stenocarpum	O in 3 tests.	No test.	O in 5 tests.	No test.	O in 8 tests.
" tenue	O in 4 tests.	F in 2 tests.	F − in 4 tests.	No test.	P + in 10 tests.
" urceolatum	O in 1 test.	No test.	No test.	No test.	O in 1 test.
" vulgare	F − in 5 tests.	G in 4 tests.	P + in 11 tests.	O in 2 tests.	F − in 22 tests.
" " (Fay's prolific)	F − in 9 tests.	F + in 8 tests.	O in 2 tests.	F − in 5 tests.	F − in 24 tests.
" " (Small)	F − in 5 tests.	G − in 8 tests.	P − in 2 tests.	P + in 3 tests.	F − in 18 tests.
" " (White	F in 5 tests.	G − in 7 tests.	O in 2 tests.	F in 1 test.	F in 15 tests.
" Wolfii	No test.	No test.	No test.	P in 1 test.	P in 1 test.
" sp. (Large gooseberry)	F − in 7 tests.	P − in 9 tests.	O in 2 tests.	O in 2 tests.	P in 20 tests.
" " (Smith's gooseberry)	P − in 5 tests.	P in 9 tests.	P − in 4 tests.	P − in 4 tests.	P − in 22 tests.
Totals	P + in 170 tests.	F − in 123 tests.	P + in 169 tests.	F − in 56 tests.	518 tests.
Percent. successful	66%	78%	57%	57%	65%

* Average of the tests given in each case.