CULTURES OF UREDINEAE IN 1912, 1913 AND 1914.[1]

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The present article is the thirteenth of a series of reports[2] by the writer upon the culture of plant rusts, beginning in 1899 and completing sixteen consecutive years. The work for the three years covered by the present report has been done under the auspices of the Indiana Experiment Station, as a part of a research project supported by the Adams Fund.

The heaviest part of the work each year falls in April and May, and during this time the regular staff of the botanical department of the Experiment Station is supplemented in order to take care of the largely increased routine part of the work. In 1912 the assistant for the culture work was Mr. L. O. Overholts, a senior student of Miami University, Ohio, recommended by Dr. Bruce Fink; in 1913 Mr. Ezra Levin, junior student with credits at the Agricultural College of Michigan, recommended by Dr. Ernst A. Bessey, was in charge; and in 1914 Mr. Carl B. Gibson, senior student of Wabash College, Indiana, recommended by Prof. H. W. Anderson, did the work.

A large number of correspondents have assisted as in previous years by sending culture material, often by supplying information from field observations, and sometimes by making special trips to secure additional material or search for cultural clues. To all such persons, and especially to those who have been to trouble and expense in response to the wishes of the writer for local aid, the most hearty thanks are accorded. Without the assistance of observers in the field, the work of studying the life histories of the rusts extending over the vast territory of North

[1] Presented before the Botanical Society of America at the Philadelphia meeting, December 29, 1914.

[2] See Bot. Gaz. **29**: 268–276; **35**: 10–23; Jour. Myc. **8**: 51–56; **10**: 8–21; **11**: 50–67; **12**: 11–27; **13**: 189–205; **14**: 7–26; Mycol. **1**: 225–256; **2**: 213–240; **4**: 7–33, 49–65.

America, many species of which are local, would proceed much more slowly.

An important aid in bringing together information regarding relationship of the rusts, and especially regarding obscure species, and in securing cultural material of critical forms, has been the excursions, often of considerable length, undertaken by the writer and members of his staff.

Early in April, 1912, Dr. F. D. Kern and the writer paid a visit to Auburn, Ala., where in company with Prof. F. E. Lloyd, field conditions of *Peridermium fusiforme* and *Puccinia angustatoides,* the latter on *Rynchospora,* were studied.

In the latter part of May, 1912, the writer and Mr. F. J. Pipal spent two days in LaGrange county on the northern border of Indiana, in a vain search for the alternate host of the *Carex* rust, *Puccinia vulpinoidis.*

An excursion on the last of May, 1912, was made to the coast of Maine by Mr. C. R. Orton and the writer. The localities visited were on the Isle au Haut, where the writer had found a number of imperfectly known rusts during several vacational sojourns. A station for the *Puccinia* on *Carex maritima* on Deer Isle was also visited. All previous observations had been made between July and October, and this long journey of over a thousand miles was for the purpose of seeking out probable aecial hosts under spring conditions. Upon the return journey, Mr. Orton stopped in Vermont and secured cultural material, especially forms on *Carex.*

Between June 17 and 20, 1912, the writer made observations in company with Dr. J. J. Davis about Madison, Wis., and northward.

From the middle of July to the middle of August, 1912, Dr. Kern and the writer traveled over a thousand miles through the high mountains of southern Colorado, going west through the middle of the state, and returning along the southern border. A week was spent in the wonderful valley at Ouray and some days at Pagosa Springs. Very helpful information was gleaned regarding grass rusts, and particularly of the leaf and stem forms which the older mycologists listed as *Puccinia graminis* and *P. rubigo-vera.*

Three weeks of August, 1913, were spent in company with Mr. H. C. Travelbee, in northern Michigan in the vicinity of Leland. Here very abundant field confirmation was obtained of the correctness of the 1913 spring culture work in associating *Puccinia vulpinoidis* with aecia on *Solidago,* and material was secured for repeating the work.

Two days were profitably given in November, 1913, accompanied by Dr. F. D. Fromme, to an exploration of the Kankakee marshes in northern Indiana, and as much time in December following, accompanied by Mr. C. A. Ludwig, to a reconnoissance about French Lick in southern Indiana.

During February and the early part of March, 1914, an extended trip by Dr. Fromme and the writer was made through the Southwest. Field work began at Denison, on the northern border of Texas. At Denton the localities made interesting to uredinologists by the extended field work of Mr. W. H. Long were visited. Stops on the way southward to Austin, and a divergence to Houston and Galveston, gave interesting results. Observations in the arid region were made principally at San Antonio and El Paso, Texas, the region about the Agricultural College, N. Mex., and at Douglas and Tucson, Ariz. At Tucson through the kindness and material assistance of Dr. D. T. MacDougal and his corps of investigators at the Desert Botanical Laboratory, the rust flora of the vicinity was examined, and a very important culture on *Brodiaea* was carried to completion.

The dominant ideas actuating the above mentioned geographical explorations are not so much those of the ordinary collector, to find new species, but rather those of the student, to secure additional knowledge of species already named but imperfectly known, and to gather facts bearing upon relationships.

To indicate the extent of the labor involved in securing the results recorded in this paper the following statistics are given. During the three seasons covered by this report, 380 collections with resting spores, and 68 with active spores were available, but scarcely one third of those with resting spores could be made to germinate. To test the germinating condition of the spores over 2500 drop cultures were made. Altogether 650 sowings were undertaken upon growing hosts and 84 infections obtained.

NEGATIVE RESULTS.—It has been customary in these reports to record failures to ascertain the alternate host, when sowings were made with spores known to be capable of germination and made upon plants that were in proper condition for infection. As the work progresses, and fewer species are left to be connected with alternate hosts, the need of such records diminishes, especially as more and more dependence is placed upon field observations for the clues to relationship. A few trials during the last three years with negative results appear to be sufficiently significant to be worthy of record at this time.

1. PUCCINIA MCCLATCHIEANA Diet. & Holw.—A collection of this species on *Scirpus microcarpus* (*S. rubrotinctus*), from Vaughns, Washington Co., N. Y., sent by Mr. Stewart H. Burnham, was used for sowings made April 1, 1914, on *Chelone glabra, Hydrophyllum virginicum, H. Fendleri, Actaea alba, Dirca palustris,* and *Iris versicolor,* all without infection.

This species has been confused with *Puccinia angustata* Peck. The name was first applied to a Californian collection thought to be on *Scirpus sylvaticus,* but now determined as *S. microcarpus.* It is a common species along the Pacific coast on the last named host, known in one instance as far into the mountains as Belgrade near Bozeman, in southwestern Montana. It also occurs along the Atlantic coast on the same host (usually called *S. rubrotinctus*), being known from Nova Scotia to Delaware, and inland as far as Albany, N. Y. It was a collection of this species and host that was cited by Peck in establishing his *Puccinia angustata,* as on "*Scirpus sylvaticum,*" from West Albany, N. Y. No clues to the identity of the alternate host have yet been secured.

2. PUCCINIA CRYPTANDRI Ellis & Barth.—A good teliosporic collection of this rust on *Sporobolus cryptandrus* was obtained by Dr. Fromme and the writer February 20, 1914, at Mesilla Park, N. Mex., and sown March 20 on *Sphaeralcea lobata, S. incana,* and *Callirhoe digitata.* Eight days later it was sown on other plants of *S. incana* and *C. digitata,* and on *Hibiscus militaris.* Again on March 9, it was sown on *Hydrophyllum Fendleri, Phacelia tanacetifolia, Thalictrum Fendleri,* and *Abronia umbellata.*

A collection similar to the last was obtained on the preceding day, but thought at the time to be *Puccinia tosta,* which was

sown April 17 on *Lithospermum officinale, Aesculus glabra, Eleagnus argentea, Lepargyraea canadensis,* and *Doellingeria umbellata.* It was sown again March 20 on *Sphaeralcea lobata, Callirhoe digitata* and *C. involucrata.* No infection was secured.

This is the first attempted culture of this species with teliospores, although once grown from amphispores.[3] Most collections show only the amphisporic stage of the rust. No clue to the alternate host has yet been obtained.

3. PUCCINIA EMACULATA Schw.—This exceedingly common rust on *Panicum capillare* has been used in previous years for sowings on 26 different species of hosts with no infection.[4] A careful morphological study shows that the species in its uredinial and telial conditions is very like *Puccinia Pammelii* Arth. (*P. Panici* Diet.), occurring commonly on *Panicum virgatum,* whose aecia have been grown upon *Euphorbia corollata.* Since this fact was ascertained, attempts have been made to grow *P. emaculata* upon *Euphorbia corollata.* Telial material from the vicinity of Lafayette, Ind., was sown accordingly on April 28, 1913, March 24, 31, and April 6, 1914. Material collected by Dr. Fromme at Lakehurst, N. J., was sown May 8, 1914, on both *E. corollata* and *E. cyparissias.* A collection from Lafayette was also sown March 31, 1914, on *Chelone glabra,* and *Dirca palustris,* which had not previously been tried. All attempts were equally fruitless. It is hoped that some time a fortunate field observation may lead to the solution of the problem.

4. UROMYCES RHYNCOSPORAE ELLIS.—No satisfactory field clues to the alternate host of this species have yet been obtained. Morphological study has led to the suggestion, improbable as it may seem at first, that it can belong to the very common *Carex-Aster-Solidago* complex. To test this suggestion, material obtained by Dr. Kern and the writer at Auburn, Ala., was sown April 22, 1912, on *Aster paniculatus, Solidago canadensis,* and *Helianthus angustifolius.* Another set of sowings was made on May 8 following upon other plants of the same three hosts, and on *Ruellia strepens,* and *Apocynum cannabinum.* No infection

[3] Jour. Myc. 14: 20. 1908.

[4] Bot. Gaz. 35: 12. 1903; Jour. Myc. 8: 52. 1902; 10: 10. 1904; 12: 12. 1906; 13: 192. 1907; 14: 11. 1908; and Mycol. 1: 230. 1909.

was obtained. Cultures were attempted on *Menyanthes* and *Decodon* in 1907, also without results.[5]

5. UROMYCES SPOROBOLI E. & E.—While on a visit to Mr. E. Bartholomew at Stockton, Kans., in August, 1911, the spot was pointed out where this rust on *Sporobolus longifolius* had been observed for several seasons following close upon a luxuriant development of an *Aecidium* on *Allium reticulatum,* as if the two might have genetic connection. Excellent material for testing the assumption was supplied the following spring, and a sowing was made April 29, 1912, upon *Allium reticulatum,* and also on *Malvastrum coccineum, Cassia chamaecrista, Baptisia bracteata, Apios tuberosa, Corydalis aurea, Zanthoxylum americanum, Physalis pubescens, Asclepias verticillata, Vagnera stellata,* and *Erigeron annuus,* all known to have aecia of uncertain connection, but without infection.[6]

SUCCESSFUL CULTURES SUPPLEMENTING PREVIOUS WORK.—The facts derived from growing the following species of rusts supplement those obtained from previous cultures in this series or from cultures recorded by other American or European investigators. In some cases the additional information recorded is of as great value as if it were entered under the next heading of cultures not before reported. For instance, the hitherto accredited species, *Puccinia vulpinoidea, P. Dulichii,* and *P. tosta,* are reduced to synonymy, and in so far simplify the naming of collections, beside permitting of a clearer conception of the variation of specific characters. A few cultures were made which are not reported, as they add no new facts to those already established.

CULTURES OF 1912

1. PUCCINIA GROSSULARIAE (Schum.) Lagerh.—The following successful cultures were made, all being sown on *Ribes Cynosbati.*

From *Carex pubescens,* Lafayette, Ind., sown April 20, showing pycnia April 29, and aecia May 9.

[5] Jour. Myc. 14: 12. 1908.

[6] For previous attempts see Bot. Gaz. 35: 11. 1903; and Mycol. 1: 13. 1912.

From *Carex crinita,* St. Anne de Bellevue, Quebec, sown May 8, showing pycnia May 16, and aecia May 24.

From *Carex arctata,* St. Anne de Bellevue, Quebec, sown May 8, showing pycnia May 22, and aecia May 27.

From *Carex tenuis,* St. Anne de Bellevue, Quebec, sown May 13, showing pycnia May 22, and aecia May 27.

In the report of cultures for 1910[7] the status of the name *P. albiperidia,* as representing a distinct species of *Carex-Ribes* rust, was discussed, but left somewhat unsettled. It was, however, thought to belong to a form possessing urediniospores with one basal pore, while the more common form on the same hosts, *P. Grossulariae,* has urediniospores with three equatorial pores. Subsequently Mr. C. R. Orton went over the material involved, including the type of *P. albiperidia,* and concluded[8] that this name should be a synonym of *P. Grossulariae,* and that the form having urediniospores with one basal pore is entitled to be considered a distinct species to which he gave the name *P. uniporula,* a species correlated with *Uromyces uniporulus* Kern, the aecia of both species being unknown.

To gather further information I have had single sori removed from the type collections of both species of *Puccinia* involved, and have had the spores of each sorus separately counted by using a mechanical stage. The results are given in the following table. The type of *P. albiperidia* is on wintered-over leaves, having been gathered April 30, 1901, at Lafayette, Ind., and provides few urediniospores, while that of *P. uniporula* was gathered August 20, 1910, at London, Ontario, and gives a fair number of urediniospores. Both types are on *Carex pubescens.* As usual when urediniospores are taken from mature telial sori, many of the spores are not in condition to show the pores. When the pores could not be ascertained with fair certainty, even after using lactic acid or chloral hydrate with iodine, the spores have been classed as uncertain. It was also necessary to take the number of cells in the teliospore into account, as *Carex pubescens* also bears *Uromyces uniporulus,* chiefly distinguishable by the teliospores.

[7] Mycol. 4: 13–15. 1912.

[8] Mycol. 4: 200, 201. 1912.

SPORES FROM TYPE COLLECTIONS OF *Puccinia albiperidia* and *P. uniporula*: EACH SORUS GIVEN SEPARATELY.

	Number of Sorus	Teliospores with 1-cell (*Uromyces*)	Teliospores with 2-cells (*Puccinia*)	Urediniospores with One Basal Pore	Urediniospores with Three Equatorial Pores	Urediniospores with Pores Uncertain
Puc. albiperidia	1	0	Not counted	0	0	0
	2	0	231	0	0	0
	3	0	317	0	0	0
	4	0	363	3	0	1
	5	0	886	4	0	2
	6	1	327	0	1?	4
	7	29	1325	0	0	3
	8	314	3	0	1?	0
	9	422	1	0	0	0
	10	697	2	0	0	1
	11	Not counted	0	0	0	0
Puc. uniporula	12	0	142	17	2	5
	13	3	853	4	1	5
	14	3	871	3	0	1
	15	4	1455	5	0	1
	16	5	19	12	1	7

Taking first the two columns of teliospores in the above table, it may be assumed that when a few only of either one- or two-celled teliospores occur in a sorus they are to be considered as incidental, possibly mesosporic. We may exclude from our present consideration four sori (8 to 11 incl.) from the type of *P. albiperidia,* as belonging to another species, *Uromyces uniporulus,* in termixed on the same leaf blades.

Of the remaining seven sori taken from the type of *P. albiperidia,* two of them (numbers 4 and 5) show a few urediniospores with one basal pore, and one sorus (number 6) shows one urediniospore with apparently three equatorial pores, while all others give no urediniospores whose pores could be made out with certainty.

Of the five sori (12 to 16 incl.) taken from the type of *P. uniporula* all show a number of urediniospores with one basal pore, and in addition three of the sori (numbers 12, 13, and 16) show urediniospores with three equatorial pores, as well as a number of spores whose pores could not be located. It is curious to note that in this type material of *P. uniporula* about one tenth of the urediniospores possess equatorial pores, and that these spores are intermixed in the same sori with the one-pored spores.

So far as the morphological evidence goes, there appears to be

no absolute difference between the types of *P. albiperidia* and *P. uniporula.* But *P. albiperidia* has been cultured on *Ribes,* producing aecia that can not be distinguished from those *Carex* rusts which show urediniospores with equatorial pores only. Whether aeciospores grown from *P. albiperidia* material would reproduce urediniospores, when sown back on a suitable *Carex,* with only three-pored or only one-pored urediniospores, or with sori containing a mixture of the two, is yet to be demonstrated. In the meantime, it seems best to use the name *P. albiperidia* as representing a form with aecia on *Ribes,* and synonymous with *P. Grossulariae,* while *P. uniporula* can be retained for such collections as show a preponderence of one-pored urediniospores. It is interesting to note in this connection that in Europe no *Carex* rust has yet been found agreeing with the uniporulate forms here discussed.

The essential specific unity of all *Carex-Ribes* rusts in both America and Europe was the conclusion reached by Dr. H. Klebahn in 1907. Dr. Klebahn's extended cultural work on this group of rusts began in 1892, and resulted in the separation of five species. In 1904 and 1906 he studied the behavior of American material grown from teliospores transmitted by the writer. Taking into account both European and American material, he came to the conclusion[9] that the six described species of *Carex-Ribes* rusts were biological forms of one collective species, for which he suggested the name, *Puccinia Ribesii-Caricis.* This conclusion is upheld by the above study, although an earlier name is preferred for the species.

2. PUCCINIA CARICIS-ASTERIS Arth. (*P. Caricis-Solidaginis* Arth.)—Five successful cultures of this rust were secured. They are as follows:

Teliospores from *Carex* sp., London, Ontario, sown April 10 on *Aster* sp., showing pycnia April 16, and aecia April 27.

Teliospores from *Carex* sp., Lafayette, Ind., sown April 11 on *Aster* sp., showing pycnia April 23, and aecia April 29.

Teliospores from *Carex retrorsa,* St. Anne de Bellevue, Quebec, sown May 14 on *Aster paniculatus,* showing pycnia May 22, and aecia May 27.

Teliospores from *Carex scoparia,* St. Anne de Bellevue, Quebec, sown May 13 on *Aster paniculatus,* showing pycnia May 22, and aecia

[9] Klebahn, Zeits. Pflanzenkr. 3: 134. 1907.

May 27; also sown same date on *Euthamia graminifolia,* showing pycnia May 22, at aecia June 4.

The significant thing about these cultures is that the material from *Carex scoparia,* which was sent by Mr. W. P. Fraser, grew on both *Aster* and *Euthamia.* The rust on this species of *Carex,* as represented in the herbarium, was for a long time considered sufficiently diverse morphologically to constitute a distinct species. Two years ago material on *Carex scoparia* from Maine was cultured on *Euthamia,*[10] but did not grow on *Aster paniculatus* or *Solidago canadensis.* This year sowings were made on the three hosts named and results obtained on two of them. It was pointed out in the discussion of the results two years ago that the *Aster-Solidago-Erigeron* group of *Carex* rusts probably constitutes a single species with a number of more or less defined races. The same view has been expressed elsewhere.[11] Numerous confirmatory facts of diverse nature have been accumulating, until it seems advisable to adjust the nomenclature to accord with present knowledge.

This species is one of the most common forms of rust in North America. It evidently is less abundant in South America and in the eastern hemisphere. The morphological study of similar European forms, rated as species, discloses some that undoubtedly are to be classed in the same category with the American group. Without taking space to record the evidence, the conclusion has been reached that the most available name for the American and European constituents of the species here represented, but possibly not the oldest one, is *Puccinia extensicola* Plowr. This name was founded on telial material from *Carex extensa,* obtained at Norfolk, England, and cultured on *Aster Tripoli,* and is in every way comparable with the *Carex-Aster* forms of America.[12]

3. PUCCINIA ANGUSTATA Peck.—Teliospores on *Scirpus atrovirens,* collected at Lafayette, Ind., by L. O. Overholts, were sown

[10] Mycol. 4: 15. 1912.

[11] Arthur, The physiologic aspect of the species question. Amer. Nat. 42: 246. 1908.

[12] For previous American cultures of this specific group, see Bot. Gaz. 35: 15, 21. 1903: Jour. Myc. 8: 53, 54. 1902; 11: 58. 1905: 12: 15. 1906; 14: 13. 1908; Mycol. 1: 233. 1909; 2: 224. 1910; and 4: 15, 16. 1912.

May 9 on *Lycopus americanus,* giving rise to pycnia May 16, and aecia May 24. Another collection believed to be the same rust and on the same host, collected at London, Ontario, by J. Dearness, was sown May 13 on *L. Americanus,* giving rise to pycnia May 20, and aecia May 27. Corresponding cultures have been made many times before.[13] The rust is very common throughout the eastern United States, especially northward, but has not been seen in the Rocky mountain region or on the Pacific coast. Professor Peck based the name, *Puccinia angustata,* which was published in the Bulletin of the Buffalo Society of Natural History, volume 1, page 67, July, 1873, upon material from "leaves of *Scirpus sylvaticum* and *S. Eriophorum;* West Albany and Watkins, September." Upon examination of type material, it transpires that the collection on "*S. sylvaticum*" was made at Watkins, N. Y., and that on *S. Eriophorum* at West Albany, N. Y., and furthermore, that of the two hosts cited only *S. Eriophorum,* collected at Watkins, N. Y., although the second one mentioned, bears teliospores that correspond to the description. The other collection on "*S. sylvaticum,*" found to be in reality *S. microcarpus* (*S. rubrotinctus*), bears a distinctly different form of teliospore, and must be considered to belong to some other species than *P. angustata.* The type of *P. angustata* Peck is, therefore, the collection in the herbarium of the New York State Museum, at Albany, N. Y., collected in September [1871?], at Watkins, N. Y., on *Scirpus Eriophorum,* by Prof. C. H. Peck. Thanks are due to Prof. Peck for the loan of the type material and for much assistance in ascertaining numerous facts connected therewith.

4. PUCCINIA ELLISIANA Thüm.—A collection on *Andropogon* sp., made by Dr. J. F. Brenckle, at Kulm, N. D., was used to sow, April 9, on *Viola cucullata, V. Nuttallii, V. primulaefolia, Laciniaria punctata* and *Lithospermum angustifolium,* with infection only on the two first named species of *Viola.* In both cases pycnia began to show in abundance May 8, and aecia May 12.

A number of vain attempts have been made in previous

[13] For previous cultures see Bot. Gaz. 29: 273. 1900; Jour. Myc. 8: 53. 1902; 11: 58. 1905; 13: 196. 1907; 14: 14. 1908; Mycol. 1: 234. 1909; 4: 17 and 54. 1912.

years[14] to culture this rust, thirty-five species of hosts having been used other than those used this year. Only once was a plant of *Viola* used, *V. striata,* a caulescent species on which such aecia have not yet been found, and are not very likely to occur.

The successful cultures were inspired by field observations by Dr. Brenckle, who sent us material with which to test his prediction. In addition to Dr. Brenckle's opinion there was also at hand the opinion of Mr. C. R. Orton, at that time working on the rusts in my laboratory, which was drawn from a study of correlation between this species and *Uromyces pedatatus,* in a paper read December 28, 1911, but not published until later,[15] the latter species having its aecia on acaulescent violets. Since that time Mr. W. H. Long has published[16] extended studies, both cultural and morphological, with important bearings which can not be taken into consideration in this connection.

5. PUCCINIA STIPAE Arth.—Two collections with teliospores on *Stipa comata,* gathered by Mr. E. Bethel, from different spots at Boulder, Colo., were used for cultures. One was sown May 15 on *Senecio lugens, S. spartioides,*[17] *Chrysopsis villosus, Grindelia squarrosa, Gutierrezia Sarothrae,* and *Solidago mollis,* all considered probable hosts for the aecia. Infection occurred only on *Gutierrezia Sarothrae,* showing pycnia May 22, and aecia May 27, both in abundance.

The other collection was sown May 17 on the same set of hosts with infection only on *Senecio spartioides,* showing numerous pycnia May 23, and aecia June 1.

This species has previously been cultured[18] on *Aster multiflorus, A. ericoides, A. Novae-Angliae, Solidago canadensis, Grindelia squarrosa,* and *Senecio lugens.* The present study adds two

[14] See Jour. Myc. 14: 10. 1908; Mycol. 1: 231. 1909; 2: 220. 1910; and 4: 9. 1912.

[15] Mycol. 4: 199, 200. *pl. 70, figs. 5 and 6.* 1912.

[16] Notes on three species of rusts on *Andropogon,* Phytopath. 2: 164–171. August, 1912; and Influence of the host on the morphological characters of *Puccinia Ellisiana* and *Puccinia Andropogonis,* Jour. Agric. Research 2: 303–319. July, 1914.

[17] The same host that was erroneously called *S. Douglasii* in report for 1910. Mycol. 4: 9, 11. 1912.

[18] See Jour. Myc. 11: 63. 1905; and Mycol. 4: 19. 1912.

aecial hosts to the list previously known, and further strengthens the view that the species consists of a number of loosely defined races.

6. PUCCINIA AGROPYRI E. & E.—Three collections on *Elymus canadensis* from two widely separated and very different habitats were successfully cultured. One collection made by Mr. E. Bethel at Boulder, Colo., from plants on which he had previously placed leaves of *Clematis ligusticifolia* covered with aecia, brought from thirty miles distant, was sown April 27, on *Clematis ligusticifolia, C. Douglasii, Anemone cylindrica, Delphinium Geyeri,* and *Thalictrum Fendleri,* all believed to be probable hosts of this rust, and on *Phacelia heterophylla, Hydrophyllum capitatum, H. Fendleri,* and *Onosmodium occidentale,* which have been suspected from field observations to belong to the list of hosts. Infection only occurred on *Clematis ligusticifolia,* showing pycnia May 8, and aecia May 20.

Another collection by Mr. Bethel from plants growing with aecia-bearing *Clematis lingusticifolia,* at Boulder, Colo., was sown May 14, on the same nine species of hosts, with infection only on *Clematis ligusticifolia,* showing pycnia May 21, and aecia May 29.

The third collection by Dr. Brenckle from Kulm, N. Dak., was sown on *Clematis ligusticifolia, C. Douglasii, C. virginiana, Anemone cylindrica, Delphinium* sp. from Colorado, *Thalictrum Fendleri, T. alpinum, Aquilegia caerulea,* and *A. flavescens,* all belonging to a quite possible group of hosts, and on the outlying hosts, *Phacelia heterophylla, Hydrophyllum Fendleri, Onosmodium occidentale,* and *Elaeagnus argentea.* Infection was obtained only on *Anemone cylindrica,* showing a few pycnia May 20, but without maturing aecia.

Another collection of the same rust on *Agropyron Smithii* (host determined by Prof. A. S. Hitchcock), collected by the writer at Pueblo, Colo., was sown April 29, on *Clematis ligusticifolia, C. Douglasii, Anemone cylindrica, Delphinium* sp. from Colorado, *Thalictrum Fendleri, Hydrophyllum capitatum, H. Fendleri,* and *Onosmodium occidentale,* with infection only on the first named. The pycnia began to show May 8 and aecia May 17.

Cultures from *Elymus* on *Clematis ligusticifolia* are now reported for the first time. It has seemed quite probable from field observations that the aecia occurring on this host in great abundance throughout the Rocky Mountains were probably connected with telia on other hosts than *Agropyron,* where they have usually been assigned in this country and Europe, but this is the first direct proof by cultures. In 1904 a rust on *Bromus* from Iowa, Indiana, and Wisconsin, believed to be *Puccinia tomipara* Trel., was grown on *Clematis virginiana.* In a discussion of the results[19] it was considered that the aecia were the form known as *Aecid. Clematitis* Schw., and distinct from the form in the Rocky Mountains, going to telia on *Agropyron.* The latter form, called *Aecid. Clematidis* DC., was grown in 1907[20] from Rocky Mountain material on *Agropyron,* but on the eastern host *C. virginiana,* no plants of *C. ligusticifolia* being available at the time. This was considered a demonstration that the form known and cultured in Europe as *P. Agropyri* E. & E., on *Agropyron,* is identical with the western form, but distinct from the eastern *Bromus-Clematis* rust.

In 1908 a rust on *Bromus* from the Rocky Mountains was grown on *Thalictrum dioicum* with success. The same season a similar subepidermal rust on *Agropyron* from the western mountains was grown on *Aquilegia.* These two forms were considered to represent distinct species and were named respectively *Puccinia alternans* and *P. obliterata.*[21]

The first cultural study of this group of subepidermal rusts began in 1903 with a supposed culture of *Dirca aecia* on *Bromus,*[22] an error which was rectified in the report of cultures the year following. From that time to the present morphological studies, field observations, and careful cultures have multiplied until now there seems to be no further doubt that this group of subepidermal forms, passing under various names, represents only one species, but a species broken up into a number of races of considerable

[19] Jour. Myc. 11: 62–63. 1905; also 13: 197. 1907; and Mycol. 1: 236. 1909.

[20] Jour. Myc. 14: 15. 1908.

[21] Mycol. 1: 248–251. 1909; also 2: 225. 1910.

[22] Jour. Myc. 10: 19. 1904; also 11: 62. 1905.

fixity. The telia are on *Agropyron, Elymus,* and *Bromus* chiefly and the aecia on *Clematis, Thalictrum, Aquilegia, Anemone,* and probably other Ranunculaceous hosts, and possibly on some hosts of other families.

7. PUCCINIA MONOICA (Peck) Arth.—In the report of cultures for 1911[23] record was made of sowings of teliospores from *Trisetum subspicatum* made June 20 upon two plants of *Arabis* (grown from Colorado seed), one plant of which indicated infection by a pathological change into a glomerate mass of rosettes, somewhat paler than normal. In this condition the plant passed the winter. Early in spring it began to send up a half dozen or more shoots instead of the usual single shoot of normal plants. Pycnia first were seen March 23, 1912, scattered over the considerably drawn shoots. Before there was time for the aecia to mature the plant accidentally died.

Freshly gathered plants of an *Arabis* bearing aecia, obtained May 13 at Palmer Lake, Colo., were received from Mr. Bethel, and aeciospores from them sown May 18 on leaves of *Koeleria cristata* and *Trisetum subspicatum.* Infection occurred only on the *Koeleria,* uredinia first being noticed June 18, and telia June 24.

There is no present need of adding to the general discussion of this species given in the last report of cultures.[24] We have now grown the rust from both aeciospores and teliospores, and shown that it occurs on both *Trisetum* and *Koeleria,* with some indication of biological races.

8. UROMYCES PERIGYNIUS Halst.—A collection on *Carex intumescens,* made by Dr. Charles E. Fairman at Lyndonville, N. Y., was sown April 24, on *Aster paniculatus, Solidago canadensis, Erigeron annuus, Euthamia graminifolia,* and *Onagra biennis.* On May 7 pycnia began to show in great abundance on the *Aster,* followed on May 10 by aecia. On the *Solidago* a few pycnia appeared May 8, but no aecia developed, although the host plant was in good condition.

In former cultures[25] material on this host from Nova Scotia produced infection on *Aster,* but not on *Solidago.* Material on

[23] Mycol. 4: 60. 1912.

[24] Mycol. 4: 59. 1912.

[25] See Jour. Myc. 10: 15–17. 1904; Mycol. 4: 21, 22. 1912.

other hosts from Maine and Indiana produced strong infection on *Solidago,* and in one case a sparing infection also on *Aster.* In the first culture report on the species, the close resemblance between this species and the parallel form under *Puccinia,* that we are now calling *P. extensicola,* was pointed out, and in the second report the evidence of well defined biological races was adduced. Both of these points are further emphasized by the cultures here reported.

In this connection an error should be corrected in the report of cultures for 1910. Quite anomalous results[26] were obtained in that year by sowing material of *Puccinia quadriporula* Arth. from *Carex Goodenowii* from the type locality, upon *Aster paniculatus.* It was at that time pointed out that the resulting aecia were indistinguishable from those of *P. Caricis-Asteris* Arth. A careful re-examination of the culture records has revealed the fact that the sowing on April 26, 1910,[27] was immediately preceded by a very successful sowing of *Uromyces perigynius* on another plant of the same species of *Aster.* The inference is that the supposed result from the spores of *P. quadriporula* in reality came from stray spores of *U. perigynius* accidentally intermixed during the operation, and do not represent a culture of *P. quadriporula.*

Furthermore, a careful and extended morphological study of a number of collections of *P. quadriporula,* made in different years from the type locality and its vicinity, leave no doubt that the form should be placed under *P. Grossulariae,* a *Carex* rust having aecia on *Ribes.* The four-pored feature of the urediniospore, from which the name is derived, is found to be no more marked than in some other collections proven to be a part of that species.

9. UROMYCES JUNCI (Desm.) Tul.—It was stated in the report of cultures for 1910[28] that both Mr. Bethel and Dr. Brenckle held the opinion that this species in some one of its forms would be found to have aecia on *Ambrosia psilostachya.* Both gentlemen provided material for a test the present season, which verified their prediction, as the following record of cultures shows. The telial host in each instance was *Juncus balticus.*

[26] Mycol. 4: 28. 1912.
[27] Mycol. 4: 21. 1912.
[28] Mycol. 4: 23. 1912.

Telia from	Prediction for Aecia	Date of Sowing	Host for Culture	First Pycnia	First Aecia
North Dakota ...	*Carduus*	April 22	*Carduus Flodmanii*	May 7	May 12
			Ambrosia psilostachya	——	——
Colorado	*Ambrosia*	April 23	*Ambrosia psilostachya*	May 8	May 12
			Ambrosia trifida	May 8	——
			Carduus Flodmanii	——	——
Montana	.....	May 6	*Ambrosia psilostachya*	——	——
			Ambrosia trifida	——	——
			Carduus Flodmanii	May 16	May 21
North Dakota ...	*Ambrosia*	May 11	*Ambrosia psilostachya*	——	——
			Ambrosia artemisiaefolia	May 22	May 27
			Ambrosia trifida	——	——
			Carduus Flodmanii	May 20	May 27
			Silphium perfoliatum	——	——
			Laciniaria scariosa	——	——
			Xanthium canadense	——	——
North Dakota ...	*Ambrosia*	May 11	*Ambrosia psilostachya*	May 27	——
			Ambrosia trifida	——	——
			Xanthium canadense	——	——

The three collections sent by Dr. Brenckle from Kulm, N. Dak., bore out the prediction that he had based upon field observations. One of the collections grew upon both *Ambrosia* and *Carduus*, indicating that the races are not invariably fixed. The collection sent by Mr. Bethel from Boulder, Colo., also bore out the prediction which he had based on a field observation. No suggestions came with the collection sent by Mr. Vasku from Nihill, Mont. As stated in the North American Flora (7: 238. 1912), only *Carduus* has heretofore been proven by cultures in this country to be a host to this species, although both *Ambrosia* and *Arnica* have been considered to be hosts, a conclusion derived from morphological and field studies.[29]

10. UROMYCES ACUMINATUS Arth.—A collection made by Mr. Bethel at Boulder, Colo., on *Spartina Michauxiana*, showing the characteristic slender, acuminate teliospores to which this name has been applied, was suspected from field observations to belong to aecia found on *Collomia*. Sowings were made April 29 on *Collomia linearis*, *Steironema ciliatum* and *S. lanceolatum*. Infection resulted only on *Collomia*, showing a great abundance of pycnia May 8, and aecia May 12.

This culture adds one more host experimentally proven to belong to this species, although it had been associated with the spe-

[29] For previous cultures see Jour. Myc. 14: 12. 1908; Mycol. 2: 220. 1910; 4: 22. 1912.

cies and with this particular race from morphological and field studies.[30]

11. GYMNOSPORANGIUM NELSONI Arth. (*G. durum* Kern).—Galls of this rust a half inch in diameter from *Juniperus scopulorum,* gathered by Mr. Bethel at Cimarron, Colo., were used for sowing May 25 on *Amelanchier canadensis* and *Crataegus punctatus.* Infection occurred only on *Amelanchier,* showing abundant pycnia June 4, but giving only a few aecia, first noticed July 17.[31]

12. GYMNOSPORANGIUM BETHELI Kern.—A collection of galls on small branches of *Juniperus scopulorum,* made by Mr. Bethel at Plainview, Colo., were used to sow, June 4, on *Crataegus Pringlei,* giving rise to pycnia June 14, and aecia July 17.[32]

13. GYMNOSPORANGIUM GRACILENS (Peck) Kern & Bethel.—A collection on *Juniperus utahensis,* made by Mr. Bethel at Glenwood Springs, Colo., was used for sowing on *Philadelphus coronarius,* giving an abundance of pycnia May 31, and aecia June 14. Another sowing was made at the same time on a horticultural form closely related to *P. coronarius,* imported from France, *P. Keteleerii,* which resulted in a luxuriant growth of pycnia May 30, and aecia June 22. These results confirm previous work.[33]

CULTURES OF 1913

14. PUCCINIA ALBIPERIDIA Arth.—A collection made by Mr. L. S. Orton at Walden, Vt., on a narrow-leaved *Carex,* and communicated by Mr. C. R. Orton, was used to sow, May 29, on *Ribes Cynosbati,* giving abundant infection with pycnia showing June 6, and aecia June 20. The rust was labelled by Mr. Orton *P. uniporula,* and our examination confirms this view, many urediniospores having been seen with one basal pore and none with equatorial pores. This does not, however, preclude the possibility of the infection coming from the three-pored form, which may be intermixed with the other, and the species is listed accordingly

[30] See North American Flora 7: 231. 1912. For previous cultures see Mycol. 4: 29. 1912; also Fraser in Mycol. 4: 186. 1912.

[31] For previous cultures see Mycol. 4: 61. 1912.

[32] For previous cultures see Jour. Myc. 14: 23. 1908; Mycol. 1: 240. 1909; 2: 230. 1910; 4: 25. 1912.

[33] For previous cultures see Mycol. 4: 63. 1912.

as in the similar culture work of 1912, discussed above under number 1.

15. PUCCINIA VULPINOIDIS D. & H.—A collection of this rust on *Carex vulpinoidea* (host determined by Dr. Theo. Holm) made by Mr. Overholts at Elkton, Ohio, was used to sow April 17 on *Aster paniculatus, A. Drummondii, Solidago canadensis, S. glaberrima* (*S. missouriensis* of most manuals), *S. Rugosa,* and *S. mollis.* There was no infection of *Asters,* but a most abundant infection of the four species of *Solidago,* pycnia showing in each case April 27, and aecia May 7.

Puccinia vulpinoidis has been considered a distinctive and easily recognized species on account of the covered telial sori. A careful morphological study, chiefly by Dr. F. D. Kern, had shown however, that aside from this character the spore structure and range of hosts agree with *P. Caricis-Solidaginis,* or as we now say, *P. extensicola,* and to this morphological study was due the suggestion which led to the above successful cultures. The permanently covered telial sorus must be considered in the light of this study to be associated with the structural peculiarities of the host, and not a character to be used without qualification.

16. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC.—Material on *Juniperus sibirica,* sent by Mr. Bethel from Tolland, Colo., was sown May 21 on *Crataegus cerronus* and gave rise to abundant pycnia June 1, but no aecia matured.[34]

17. PERIDERMIUM FUSIFORME Arth. & Kern.—Through the kindness of Dr. F. A. Wolf of Auburn, Ala., typical material of this striking rust was received, gathered from a grove of *Pinus taeda,* which Dr. Kern and myself had visited in April, 1912, and in which this form of *Peridermium* is very abundant.

The first collection, sent March 22, 1913, was from a main stem an inch in diameter, the fusiform gall being one and a half inches in diameter at the middle, and six inches long. It was sown March 24 on two plants of *Quercus rubra.* Uredinia began to appear sparingly on one plant by April 3, but failed to appear on the other, although telia developed on both plants April 14, in ample and perfect development.

[34] For previous cultures see Jour. Myc. 14: 19. 1908; Mycol. 1: 239. 1909; 4: 24. 1912; and 4: 56. 1912.

The second consignment was received April 5, 1913, consisting of a much larger gall, three inches in diameter by six inches long, but less typical in appearance. This material was sown April 6 on *Quercus rubra* and *Q. Phellos.* On the former, uredinia began to appear April 14, and on the latter April 18, followed by telia in both cases April 28.

This result shows without question that the form known under the name of *Peridermium fusiforme* is identical specifically with *P. Cerebrum,* both being the aecial stage of *Cronartium Quercus.* This cultural result is briefly referred to by Dr. Kern in Mycologia **6**: 112, 135. 1914. The non-appearance of the repeating stage in one case is an interesting phenomenon apparently connected with some condition of the host.

18. PERIDERMIUM CARNEUM (Bosc) Seym. & Earle.—Leaves of *Pinus taeda* bearing this rust were gathered by Prof. P. H. Rolfs, at Gainesville, Fla., February 12, 1913, and two days later were used by use to make a sowing on *Vernonia fasciculata.* Uredinia began to appear in abundance on March 3. Another collection of the rust was gathered by Mr. H. E. Stevens from *Pinus palustris* in the vicinity of Gainesville, Fla., on March 1. This material was from small plants in the open, over which leaves of *Ipomoea pandurata* well covered with *Coleosporium Ipomoeae* had been placed the previous fall. The field condition appeared to warrant the inference that the pine aecia were derived from the *Ipomoea* telia. A sowing of the material was made March 10 on *Vernonia fasciculata,* but no plants of *Ipomoea* were available for a culture. Uredinia appeared on the *Vernonia* in abundance on March 29, and in the typical form of *Coleosporium Vernoniae.*

This result does not preclude the possibility that *Coleosporium Ipomoeae* is a form of *C. Vernoniae,* but judging from the microscopic appearance of the urediniospores, that species is more likely to be a form of *C. Solidaginis* than of *C. Vernoniae.*

CULTURES IN 1914

19. PUCCINIA EXTENSICOLA Plowr.—A collection of the form known as *P. vulpinoidis,* collected by Mr. Travelbee and the writer

on *Carex vulpinoidea,* at Leland, Mich., Aug. 26, 1913, was used to sow April 2, on *Solidago canadensis* and *Aster paniculatus.* Abundant infection occurred on the *Solidago,* pycnia showing April 11, and aecia April 20, but the *Aster* remained free. The collectors found in many instances old aecia on *S. canadensis* in the field, intermixed with rusted *Carex vulpinoidea.* The inference from field observation, and also the cultural work of last year as recorded above under number 15, is confirmed by the culture.

A collection of *P. Dulichii* Syd., on *Dulichium arundinaceum,* gathered Jan. 17, 1914, at Gainesville, Fla., by Mr. H. E. Stevens, was accompanied by young aecia on a species of *Aster.* This association suggested that they might be genetically connected. A sowing from the *Dulichium* material was made, Jan. 22, on *Aster Drummondii, A. paniculatus,* and on an undetermined *Aster,* which had been obtained from a field near New Orleans, La., also on *Solidago canadensis* and *Senecio obovatus.* Another sowing from the same material was made, Jan. 31, on the same three species of *Aster,* and on *A. Tweedyi.* The only infection was a sparing production of pycnia on *Solidago canadensis,* showing Feb. 3, which did not continue into aecia. As soon as this result was noticed, another sowing from the same material was made, Feb. 4, on *Solidago canadensis,* which resulted in an abundant infection, showing pycnia Feb. 16, and aecia Feb. 25. From this result, together with a careful microscopic study of herbarium material, it is inferred that *P. Dulichii* is a part of the common *P. extensicola,* although the telial host is not a *Carex.* It is the first time that any Carex rust has been traced to a telial host outside of the genus *Carex.*

20. PUCCINIA TOSTA Arth.—A collection was made by Dr. Fromme and the writer at Mesilla Park, N. Mex., on what was thought at the time to be *Muhlenbergia Porteri,* but which later proved to be the very similar appearing *Sporobolus asperifolius.* Thinking that it was *P. Muhlenbergiae,* known to have its aecia on malvaceous hosts, it was sown, March 20, on *Callirhoe involucrata, C. digitata,* and *Sphaeralcea incana.* Infection was obtained only on the last host, pycnia showing March 27, and aecia April 3, both in great profusion. Another sowing was at once

made of the same material on *S. lobata, C. digitata, Hibiscus militaris,* and *Malvastrum coccineum,* with infection only on the *Sphaeralcea,* pycnia showing April 6, but the aecia being destroyed by aphis before maturing.

Another collection of identical appearance was made five days later than the one above, at Ysleta, Texas, a few miles from El Paso. This was sown, March 28, on two plants of *S. lobata,* on *C. digitata,* and *H. militaris.* Both plants of *Sphaeralcea* gave infection, showing pycnia April 6, but resulting in few aecia, owing to accident. Another sowing from the same collection was made, May 2, on *Napaea dioica,* without infection.

Putting the above cultural results from *P. tosta,* with the gross appearance and subsequent microscopic study, and comparing with similar data from *P. Muhlenbergiae,* there appears to be no ground upon which to keep the two forms separate. The fact that the telial hosts belong to two genera of grasses is not in this case a difference of importance, as *Sporobolus* and *Muhlenbergia* intergrade, and are kept separate upon technical grounds. The previous cultural studies[35] of *P. Muhlenbergiae* have indicated that the species is a complex of races. It has been grown on *Hibiscus militaris* and *Callirhoe involucrata,* but the similar aecia on *Napaea, Malvastrum,* and *Sidalcea* have not yet been grown, although attempted, the failure believed to be due to a lack of the proper racial telia. The above is the first successful culture with material on *Sporobolus,* although previous attempts[36] have been made.

Hereafter it will be considered advisable to treat *P. tosta* as a synonym of *P. Muhlenbergiae.*

21. PUCCINIA AGROPYRI E. & E.—A collection of this rust on *Elymus virginicus* was made by Dr. Fromme and the writer on Feb. 13, 1914, at Austin, Texas, and at the same time the observation was made that *Clematis Drummondii,* not then in leaf, was in the same spot, and abundant in the vicinity. Dormant roots of this wild Clematis were secured, and later grown for the culture work.

[35] See Jour. Myc. 11: 51. 1905; 13: 192. 1907; Mycol. 1: 251. 1909; 2: 226. 1910; and 4: 18. 1912.

[36] See Jour. Myc. 10: 10. 1904; 12: 12. 1906; Mycol. 4: 10 and 52. 1912.

A sowing of telia was made April 1 on *Clematis Drummondii, C. Douglasii, C. virginiana, Aquilegia flavescens, A. canadensis, Thalictrum Fendleri,* and *T. dioicum.* Abundant infection occurred on the first named host, but on no others, pycnia appearing April 5, and aecia April 18.

The results are in accord with the cultures of 1912, reported above under number 6, but indicate another race not met with before.

22. UROMYCES PERIGYNIUS Halst.—A collection of this species on *Carex tribuloides* made at French Lick, Ind., by Mr. Ludwig and the writer, was sown April 1 on *Aster paniculatus, A. Drummondii, A. Tweedyi, Solidago canadensis, S. rugosa,* and *Euthamia graminifolia.* Infection was secured only on *Aster Tweedyi,* and then so sparingly that it was overlooked until April 8, when the aecia were observed. Cultures for 1912 are reported above under number 8.

This species of rust from other *Carex* hosts has previously been been grown[37] on two other species of *Aster,* and five species of *Solidago.*

23. UROMYCES SCIRPI (Cast.) Burr.— Material on *Scirpus fluviatilis,* sent by Mr. E. T. Bartholomew from Madison, Wis., was sown April 22 on *Sium cicutaefolium,* giving rise to a few pycnia May 5, but without further development. Another similar sowing April 24 gave rise to an abundance of pycnia May 5, and aecia May 11.

The former cultures[38] with American material have been on *Cicuta maculata.*

24. GYMNOSPORANGIUM NIDUS-AVIS Thax.—Telial material on *Juniperus virginiana,* gathered by Dr. Fromme at Woods Hole, Mass., was sown May 11 on *Amelanchier vulgaris,* giving rise to pycnia May 19, and a great abundance of aecia June 20.[39]

25. GYMNOSPORANGIUM BOTRYAPITES (Schw.) Kern.—Telial material on *Chamaecyparis thyoides* sent by Dr. Fromme from Lakehurst, N. J., was sown May 6 on the leaves of *Amelanchier canadensis* and *Aronia arbutifolia,* with no infection on *Aronia,*

[37] Jour. Myc. 10: 15. 1904; and Mycol. 4: 32. 1912.

[38] Jour. Myc. 13: 199. 1907; 14: 17. 1908; and Mycol. 1: 237. 1909.

[39] For previous cultures see Jour. Myc. 14: 19. 1908; Mycol. 2: 230. 1910; 4: 25 and 56. 1912.

but very abundant infection on *Amelanchier,* giving pycnia May 18, and aecia October 1.

Another collection on the same host was sent by Dr. Fromme four days later from Woods Hole, Mass., and sown May 11 on leaves of *Amelanchier canadensis,* giving pycnia June 5, and aecia October 27. The results are in accord with previous cultures.[40]

26. COLEOSPORIUM VERNONIAE B. & C.—A collection of *Peridermium carneum* on *Pinus taeda,* gathered at East Lake, Fla., by Mr. H. E. Stevens, was sown April 13 on *Aster paniculatus, Solidago canadensis, Euthamia graminifolia, Laciniaria punctata, L. Langloisii* (the plant obtained from Texas), and *Vernonia fasciculata.* A sparing infection was obtained on the *Vernonia* only, uredinia being first noticed May 8.

A similar collection sent by the same collector from Gainesville, Fla., was sown May 8 on *Solidago canadensis, Laciniaria Langloisii, Elephantopus carolinianus, Amsonia salicifolia,* and *Vernonia fasciculata.* Although all the hosts used were possible hosts for such a *Peridermium,* yet infection only occurred on the *Vernonia,* showing uredinia May 25 in abundance.

Uredinia from the last culture was sown May 17 on another plant of *Vernonia fasciculata,* with abundant infection, showing uredinia May 26. Another sowing from the same source was made May 28 on *Aster paniculatus* and *Laciniaria Langloisii,* with no infection.

The results are in accord with previous cultures,[41] and add but little to our knowledge of the numerous southern species of *Coleosporium.*

SUCCESSFUL CULTURES REPORTED NOW FOR THE FIRST TIME: The following species have never before been cultivated, in America or elsewhere, so far as the writer knows. Some of those included in the above list, such as *Puccinia vulpinoidis, P. Dulichii, P. tosta,* and *Peridermium fusiforme,* might with some propriety have been placed here, as not till after the cultures were made was their true status as species known.

[40] Mycol. 1: 240. 1909.

[41] Mycol. 4: 29 and 57. 1912.

CULTURES IN 1913

1. UROMYCES ELEGANS (B. & C.) Lagerh.—This autoecious rust, very common in the Southern States, is one of the group of species which produce no uredinia, so far as known, very few of which have been cultivated. Growing plants of *Trifolium carolinianum* bearing aecia were sent by Dr. F. A. Wolf from Auburn, Ala., and the aeciospores sown March 29 on plants free from the fungus. Teliospores began to appear about April 18 as the result.

This result does not disclose whether the species possesses both primary and secondary aecia, or whether pycnia ever occur. A culture with teliospores should be kept in view.

CULTURES IN 1914

2. PUCCINIA NODOSA Ell. & Hark.—While upon a visit to the Desert Botanical Laboratory at Tucson, Ariz., an exceptional opportunity was offered to study the life history of another autoecious species of rust, which like the one last mentioned, possesses no uredinia. A strong plant of *Brodiaea pauciflora,* growing near the door of the laboratory was moistened on February 26, sprinkled with aeciospores brought from some distance, and covered with a belljar. The temperature at the time was favorable for infection, the belljar being shielded from the direct rays of the sun. The experiment was left in charge of Dr. W. A. Cannon of the Laboratory staff, who kindly forwarded the leaves on March 18, when the sori first opened. Only telia were produced.

As in the preceding case the possibility of both primary and secondary aecia occurring in the life cycle is not touched upon.

3. PUCCINIA SPLENDENS Vize.—Through the courtesy of the Desert Botanical Laboratory, Dr. Fromme and the writer were enabled to make an excursion on February 28 to the Santa Rita Mountains in the vicinity of Tucson, Ariz., where we secured teliosporic specimens of *P. splendens* on *Hymenoclea monogyra.* Through the kindness of Prof. J. J. Thornber of the University of Arizona we received after our return to Indiana a number of thrifty young plants of this host, which soon started into leaf in the green house. A sowing of teliospores was made April 7,

and another April 15, with no result. A third sowing on April 25 was better done, and gave rise to pycnia on the leaves May 6, and aecia May 20.

Aeciospores from this culture were sown May 26, which resulted in the production of uredinia June 15, not numerous but well formed. Uredinia continued to be produced until they were finally followed sparingly by telia July 10.

In every sowing an abundance of spores was used, which were applied to both leaves and stems. Tests of the spores showed unusually strong germination. Why the infection was so sparing and only on the leaves, while in the field the rust is chiefly on the stems, was not apparent. The cultures supply a knowledge of the pycnia and uredinia, neither of which were before known.

4. PUCCINIA MINUTISSIMA Arth.—Viable material of this species on *Carex filiformis* was secured at much labor especially for this work by Mr. J. Dearness of London, Ontario, from the southeastern shore of Lake Huron. A collection made in December, 1911, was sown the following spring on seven hosts of as many genera without infection. Another collection of May, 1912, was similarly tested, and even more thoroughly, without success. A collection made in November, 1913, was sown April 18, 1914, on *Decodon verticillatus,* with an abundant infection, showing pycnia April 27, and aecia May 7.

The first suggestion for this connection was made by Prof. James B. Pollock of the University of Michigan, who wrote on August 3, 1909, as follows: "I found a rust on a patch of *Carex filiformis,* forming a half circle with a radius of about two rods around a specimen of *Decodon verticillatus,* some of whose leaves had an *Aecidium* on them. I send herewith specimens of both. No other *Aecidium* was found near the rusted sedge. The whole situation seems to me to indicate very closely the Decodon plant as a center of infection for the *Carex* rust."

The aecial stage of this rust is *Aecidium Nesaeae* Ger., but *Puccinia Nesaeae* Ellis & Ev. does not belong here, having been founded on a telial collection with the host erroneously determined. The error was detected by Prof. E. W. D. Holway.

5. GYMNOSPORANGIUM ELLISII (Berk.) Farl.—Material on *Chamaecyparis thyoides* was sent by Dr. Fromme from Lakehurst

N. J., and sown May 6 on *Myrica cerifera,* giving rise to pycnia May 15, and aecia June 6. This most interesting result was in accord with field observations made by Dr. Fromme, who has recorded the steps which led to the inference of relationship, and has also discussed the results, in a paper[42] anticipating this report.

The aecia of this species are of the aecidioid form, and not roestelioid, as in the majority of the species of the genus. Moreover, the host belongs to a family more divergent from the Malaceae, which bears most of the Gymnosporangial aecia, than heretofore supposed to be possible. The telial stage was once made the basis of a separate genus, *Hamaspora,* on account of the slender, more than two-celled teliospores. Completing a knowledge of the life history of a species with so many outlying characters is an especially notable achievement.

SUMMARY

The following is a complete list of the successful cultures made during the years 1912, 1913, and 1914. It is divided into two series, species that have previously been grown in cultures and reported by the writer or other investigators, and species whose culture is now reported for the first time.

A. SPECIES PREVIOUSLY REPORTED

1, (8) and 14. PUCCINIA GROSSULARIAE (Schum.) Lagerh. (*P. albiperidia* Arth., *P. quadriporula* Arth.)—Teliospores from *Carex arctata* Boott, *C. crinita* Lam., *C. pubescens* Muhl., and *C. tenuis* Rudge, sown on *Ribes Cynosbati* L.

2, 15 and 19. PUCCINIA EXTENSICOLA Plowr. (*P. Caricis-Asteris* Arth., *P. Caricis-Solidaginis* Arth., *P. vulpinoidis* D. & H., *P. Dulichii* Syd.).—Teliospores from *Carex retrorsa* Schw., sown on *Aster paniculatus* Lam.; from *Carex scoparia* Schk., sown on *A. paniculatus* Lam. and *Euthamia graminifolia* (L.) Nutt.; from *Carex vulpinoidea* Michx., sown on *Solidago canadensis* L., *S. glaberrima Martens, S. rugosa Mill.* and *S. mollis* Barth.; from *Dulichium arundinaceum* (L.) Britt., sown on *Solidago canadensis* L.

[42] Fromme, D. A. A new Gymnosporangial connection. Mycol. 6: 226–230. 1914.

3. PUCCINIA ANGUSTATA Peck.—Teliospores from *Scirpus atrovirens* Muhl., sown on *Lycopus americanus* Muhl.

4. PUCCINIA ELLISIANA Thüm.—Teliospores from *Andropogon* sp., sown on *Viola cucullata* Ait. and *V. Nuttallii* Pursh.

5. PUCCINIA STIPAE Arth.—Teliospores from *Stipa comata* Trin. & Rupr., sown on *Gutierrezia Sarothrae* (Pursh) B. & R., and *Senecio spartioides* T. & G.

6 and 21. PUCCINIA AGROPYRI E. & E.—Teliospores from *Elymus canadensis* L., sown on *Clematis ligusticifolia* Nutt., and *Anemone cylindrica* A. Gray; from *Elymus virginicus* L., sown on *Clematis Drummondii* T. & G.; and from *Agropyron Smithii* Rydb., sown on *Clematis ligusticifolia* Nutt.

7. PUCCINIA MONOICA (Peck) Arth.—Teliospores from *Trisetum subspicatum* (L.) Beauv., sown on *Arabis* sp., and aeciospores from *Arabis* sp., sown on *Koeleria cristata* (L.) Pers.

20. PUCCINIA MUHLENBERGIAE A. & H. (P. *tosta* Arth.).—Teliospores from *Sporobolus asperifolius* (Nees & Meyen) Thurb. sown on *Spaeralcea incana* Torr. and *S. lobata* Wooton.

8 and 22. UROMYCES PERIGYNIUS Halst.—Teliospores from *Carex intumescens* Rudge, sown on *Aster paniculatus* Lam., and *Solidago canadensis* L.; from *Carex tribuloides* Wahl., sown on *Aster Tweedyi* Rydb.

9. UROMYCES JUNCI (Desm.) Tul.—Teliospores from *Juncus balticus* Willd., sown on *Ambrosia psilostachya* DC., *A. trifida* L., and *Carduus Flodmanni* Rydb.

10. UROMYCES ACUMINATUS Arth.—Teliospores on *Spartina Michauxiana* A. S. Hitch., sown on *Collomia linearis* Nutt.

23. UROMYCES SCIRPI (Cast.) Burr.—Teliospores from *Scirpus fluviatilis* (Torr.) A. Gray, sown on *Sium cicutaefolium* Schrank.

11. GYMNOSPORANGIUM NELSONI Arth. (*G. durum* Kern).—Teliospores from *Juniperus scopulorum* Sarg., sown on *Amelanchier canadensis* (L.) Medic.

12. GYMNOSPORANGIUM BETHELI Kern.—Teliospores from *Juniperus scopulorum* Sarg., sown on *Crataegus Pringlei* Sarg.

13. GYMNOSPORANGIUM GRACILENS (Peck) Kern & Bethel.—Teliospores from *Juniperus utahensis* (Engelm.) Lemmon, sown on *Philadelphus coronarius* L. and *P. Keteleerii* Carr.

16. GYMNOSPORANGIUM CLAVARIAEFORME (Jacq.) DC.—Telio-